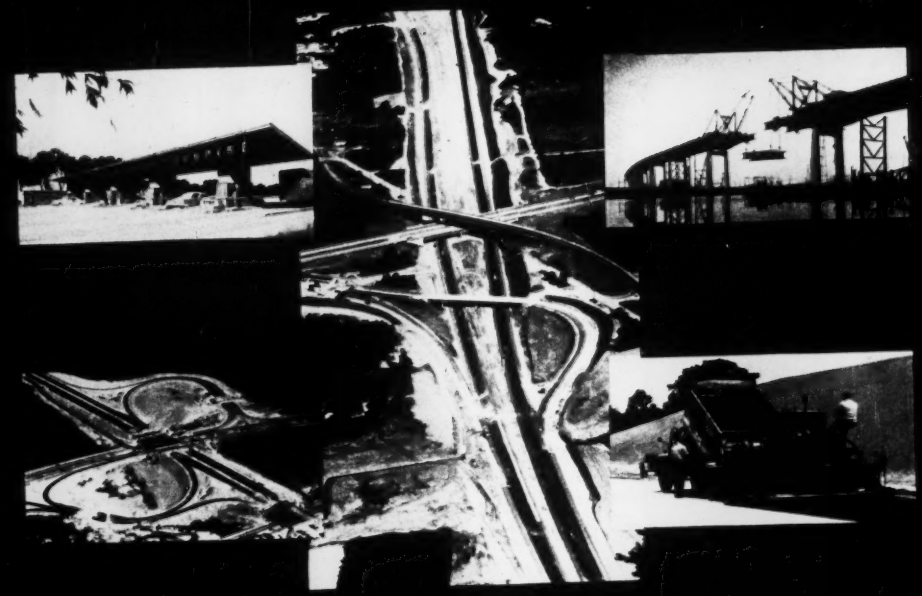
CIVIL ENGINEERING

JANUARY 1952



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New York, N. Y.

STEEL CONTRACTOR
American Bridge Co.
Ambridge, Pa.

ENGINEERS
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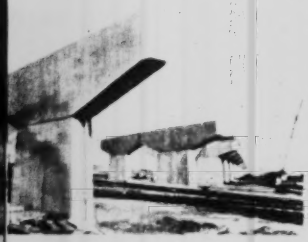
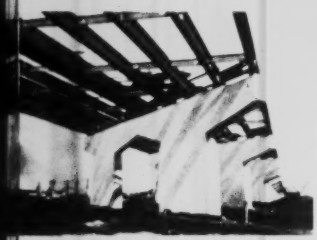
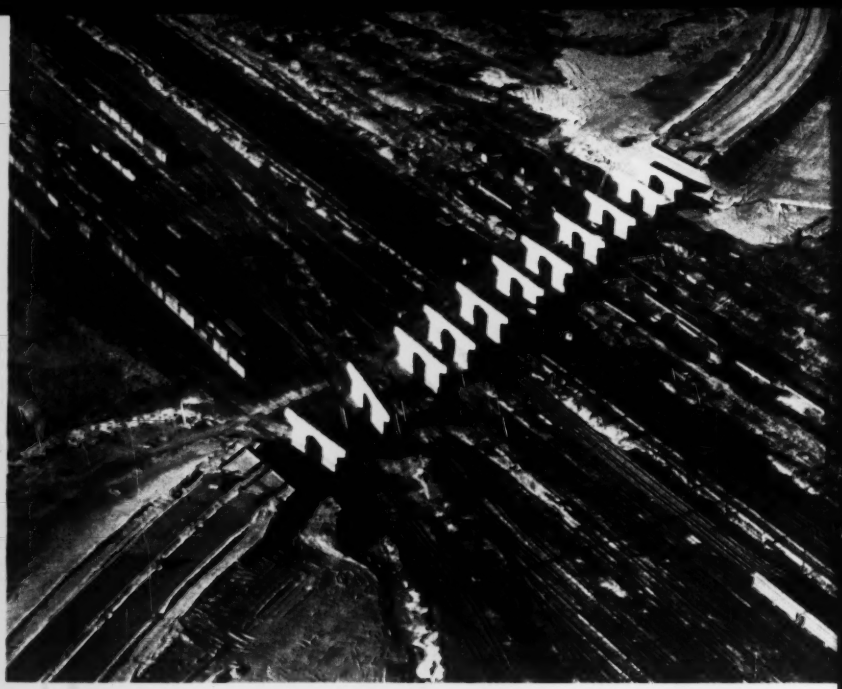
Tammen & Bergendoff
New York, N. Y.

ARCHITECTS
Alfred Fellheimer,
Steward Wagner
New York, N. Y.







Raymond SALUTES

THE NEW JERSEY TURNPIKE

RAYMOND IS PROUD to have played a vital part in the creation of this fabulous new cross-state highway. The railroad overpass near Ridgefield, N. J., is just one of several projects on the Turnpike that rest on Raymond Piles. 778 Raymond Pipe Step-Taper Piles driven for 11 piers and 2 abutments, with an average length of 120′ and a total footage of 93,283′ were used on this overpass—just another example of the part Raymond is playing in building tomorrow's world today.

SCOPE OF RAYMOND ACTIVITIES
Soil Investigations, Pile and Caisson Foundations, Underpinning, Harbor and River Improvements and Cement Mortar Lining of Pipelines by the Centrilite and Lafe Processes.

Raymond
CONCRETE PILE CO.

140 CEDAR STREET • NEW YORK 6, N. Y.

BRANCH OFFICES in the principal cities of the United States and Central and South America.

How Bitumuls-sand "Stockpiling" makes road-crew time more productive

LOCAL SAND-PITS become sources of sound material for cold paving mixtures and wise labor utilization when Southern ingenuity puts winter-idled road crews to work with BITUMULS.®

No special equipment is needed. Sand used in this project is from abandoned pits or river banks.

Bitumuls HCM, even in "full formula" amount, makes an economical cold mix which is stockpiled during slack winter months for use during warmer summer weather. Workability is retained almost indefinitely without sacrifice of toughness, cohesion, or stability.

The Bitumuls-sand mix is suitable for surface, leveling courses or thick bases even where subgrade deflection may be anticipated.

Louisiana State Highway Engineers report that these rich sand mixes sustained far less damage than other types of paving during the unprecedented "freeze" of the 1950 winter season.

Mixing Grades of Bitumuls are ideal for treating virtually all available aggregates. Quick-Setting Grades of Bitumuls are favored the world over for armorcoat and macadam work. High Viscosity Bitumuls is recognized as standard for surface treating.

Nation-wide there are Bitumuls Engineers working out of strategically located plants. These men are specialists, qualified by training and varied experience to consult with you, to your advantage, about your paving needs . . . roads, parking areas or airports.

Bitumuls is ready for prompt delivery to your job site.

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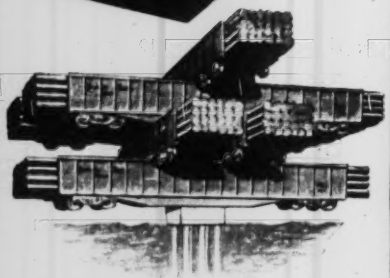
Manufacturers of Asphalt and Asphaltic Products

SUPPLIERS OF ASPHALT FOR THE TURNPIKE

CIVIL ENGINEERING, The Magazine of Engineered Construction, January, 1952 Vol. 22, No. 1 Published monthly by the American Society of Civil Engineers Publication office 20th and Northampton Streets, Easton, Pa. Editorial and advertising departments at the headquarters of the Society, 33 West 39th Street, New York, N. Y. Price $.60 a copy, $5.00 a year in advance, $4.00 a year to members and to libraries and $2.50 a year to members of Student Chapters Canadian postage .75¢ and foreign postage $1.50 additional Entered as second class matter September 23, 1930, at the Post Office, Easton, Pa., under the Act of August 24, 1912, and accepted for mailing at a special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized on July 5, 1918.

450 TONS ...What a Pile!

AND WHAT A PILE TEST!



Freight cars weren't stacked up of course—but a weight equal to six capacity-loaded freight cars, 450 tons, was placed on a group of six Button-Bottom* piles to test the bearing value of a gravel-clay stratum at considerable depth.

WRITE FOR LITERATURE

CAST-in-place thin shell concrete piles, 12 in. dia. for the entire 80 to 100 ft. length, pass through "Boston blue clay" and take their bearing on a deep-lying gravel-clay stratum. Heretofore, more expensive types—pipe, steel H-beam, or composite piles—were required in this soil.

A group of six piles was load-tested to 450 tons, 1½ times design load, possibly the heaviest pile test ever made in this country. After removal of the load the measured permanent settlement was only ⅛ in.

633 Button-Bottom* piles are being driven for the 16-story Eastgate Apartments to provide faculty housing on the campus of Massachusetts Institute of Technology at Cambridge, Mass. George A. Fuller Company is general contractor. Thomas Worcester, Inc. have charge of field engineering.

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INDUSTRIAL PLANTS, POWER PLANTS, STEEL PLANTS, PIERS AND DOCKS, WAREHOUSES, BRIDGES, AIRPORTS, HOUSING PROJECTS, SCHOOLS, COMMERCIAL BUILDINGS, ETC.

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WESTERN FOUNDATION CORPORATION

308 W. Washington St., Chicago 6, Ill. • 2 Park Avenue, New York 16, N. Y.

You're looking at the dam from the cableway operator's control station. The track cable extends from the head tower 2420 feet across the river canyon to the tail tower (upper circle). The 8-yard bucket (lower circle) is loaded at a dock beneath the control station. G-E amplidyne control provides fast operation and flexibility, needs only minimum maintenance.

WORLD'S FASTEST CABLEWAY speeds dam construction . . . electrically!

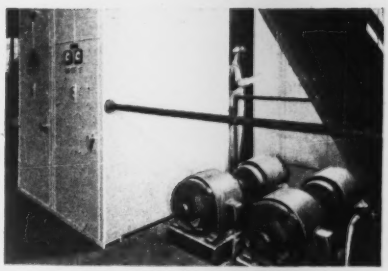
G-E powered rig at Pine Flat Dam hoists and hauls at same time; has poured 4000 yards in single day!

At Pine Flat Dam on the Kings River near Fresno, California, the General Electric powered cableway—fastest in the world—is setting new pouring records to help build the world's ninth highest dam. A Corps of Engineers project, the dam is being built by Pine Flat Contractors Associated Companies.

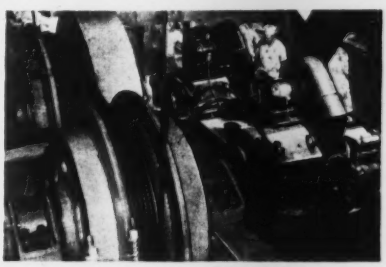
The Pine Flat rig, built by Willamette Iron and Steel Co., is the first ever designed with G-E amplidyne control—for faster acceleration, greater precision, smoother operation. In addition, a new concept of power application permits hoisting and hauling at the same time. Automatic braking makes operation safer. Smoother acceleration lessens wear on cables and other equipment. And power losses during acceleration and deceleration are reduced.

For faster, safer, easier operation of *your* construction equipment, electrify with G-E drives and power distribution systems—backed by G-E engineering help in application, installation, and service. *General Electric Co., Schenectady 5, N. Y.*

Ask him today! **Whether you buy or build construction equipment, your G-E representative can show you how to do a better job—at lower cost—by complete electrification. Write him now, and he'll call on you at your convenience.**



Key to rig's speed—G-E amplidynes in head tower for hoist and haul drives provide smooth adjustable voltage control by limiting current during acceleration.



Carriage drive motors are built by G.E. for extra-tough applications like this. The completely separate two-motor hoist drive is also located in the head tower.

GENERAL ELECTRIC

664-20

THE MEMBERSHIP OF A C. I. P. Century Club now has

96%
OF ALL 6-INCH AND LARGER CAST IRON WATER MAINS EVER LAID IN 25 REPRESENTATIVE CITIES ARE STILL IN SERVICE
Based on the findings of a survey conducted by leading water works engineers.

CAST IRON

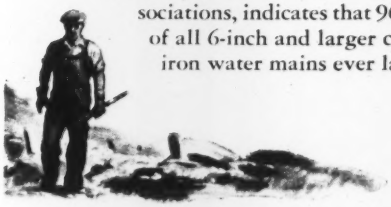
CAST IRON PIPE

DISTINGUISHED CLUB...
38 Members*

The Cast Iron Pipe Century Club is probably the most unusual club in the world. Membership is limited to municipal, or privately-owned, water and gas supply systems having cast iron mains in service for a century or more.

Although the Club is formally constituted, there are no dues, no regular meetings, and no obligations other than to inform the Recording Secretary if and when the qualifying water or gas main is taken out of service, or, sold for re-use.

In spite of the unique requirement for membership, the Club roster grows, year by year. And why not, when a survey sponsored by three water works associations, indicates that 96% of all 6-inch and larger cast iron water mains ever laid



in 25 representative cities are still in service. And when answers to a questionnaire, mailed to gas officials in 43 large cities, show that *original* cast iron mains are still in service in 29 of the cities.

If your records show a cast iron main in service, laid a century or more ago, the Club invites you to send for a handsome framed Certificate of Honorary Membership. Address Thomas F. Wolfe, Recording Secretary, Cast Iron Pipe Century Club, Peoples Gas Bldg., Chicago 3, Illinois.

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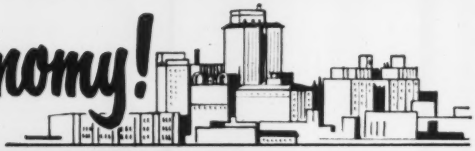
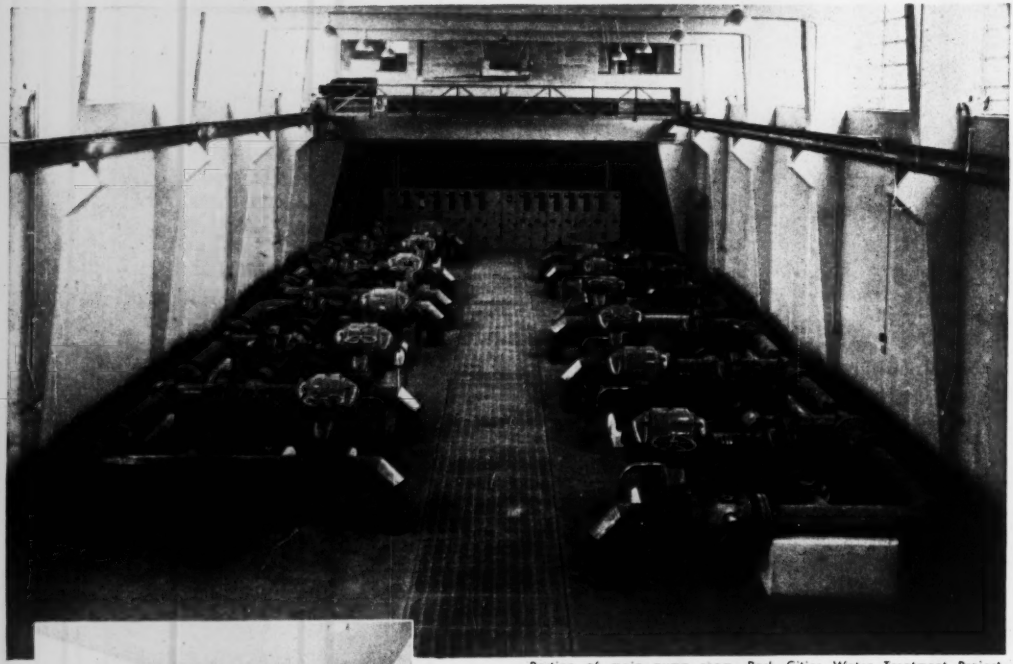
*8 new members in 1951

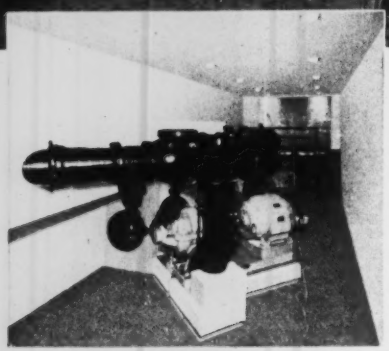
SERVES FOR CENTURIES

Now...Dallas Park Cities are pumping with Economy!





Portion of main pump room, Park Cities Water Treatment Project. Shown are 13 of the 22 Economy Pumps installed on this project.



View in University Park Booster Station, part of the Park Cities project. These Economy Pumps boost the pressure going to the overhead storage tank, located 5 miles from the treatment plant.

in new Park Cities, Texas, Water Treatment Plant

Economical operation over a period of years was a primary requisite of the pumps for Park Cities Water Treatment Project, Dallas. In selecting pumps, Powell & Powell, Consulting Engineers, drew up specifications which took into consideration cost of equipment, efficiency of each unit and efficiency of units operating in series, plus rigid structural requirements and refinements of mechanical detail. Under this very exacting evaluation formula, Economy Pumps, designed especially for water works service, supplied by the Lone Star Pump and Machinery Co., were selected, on the Dallas County project.

It pays to specify Economy Pumps for water supply. For detailed information and illustrated catalogs write today to Dept. BK-1

Economy Pumps, Inc.

SEDGLEY AVE., AT 19th AND LEHIGH, PHILADELPHIA 32, PA.

Keeping Raw Sewage Out of San Francisco Bay

San Francisco's new $4,486,000 North Point Sludge Treatment Plant is the biggest move in the Golden Gate city's $20,000,000 program to prevent dumping raw sewage into bay waters. It substantially augments existing sewage treatment facilities by serving sixty per cent of the city—an area bordered roughly by Twin Peaks, the Presidio and Islais Creek.

Playing an important part in the operation of the North Point Plant are ten 100-ft. diam. digestion tanks equipped with P.F.T. Floating Covers, a 55-ft. 6-in. diam. gasholder with a P.F.T. spirally guided cover and a 15,000-gal. Horton elevated water tank. All these structures were fabricated and erected by Chicago Bridge & Iron Company.

Gas formed in the sludge digestion process is collected in the digestion tanks at a pressure of 5 inches of water. It is then metered and piped to the gasholder where moisture is precipitated and the supply to the compressor is equalized for distribution to the mains.

The receiving and thickening, the digestion and the elutriation and filtration units of the Sludge Plant will receive and treat the settled sludge from 91 mgd of sewage flow through the North Point and Southeast primary sewage treatment plants. The dryer units will handle that sludge plus 10,000 pounds per day of filter cake trucked cross-town from the Richmond-Sunset plant for further drying.

No one living near the North Point plant will be able to tell odor-wise what the plant is doing. Fumes are drawn off, deodorized and dissipated into the air from a two hundred foot stack.

Floating covers—spirally guided covers and elevated tanks are only a few of the many types of steel plate work we do. Write our nearest office for information. There is no obligation on your part.

CHICAGO BRIDGE & IRON COMPANY

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Chicago 4	2199 McCormick Bldg.	Los Angeles 17	1556 General Petroleum Bldg.
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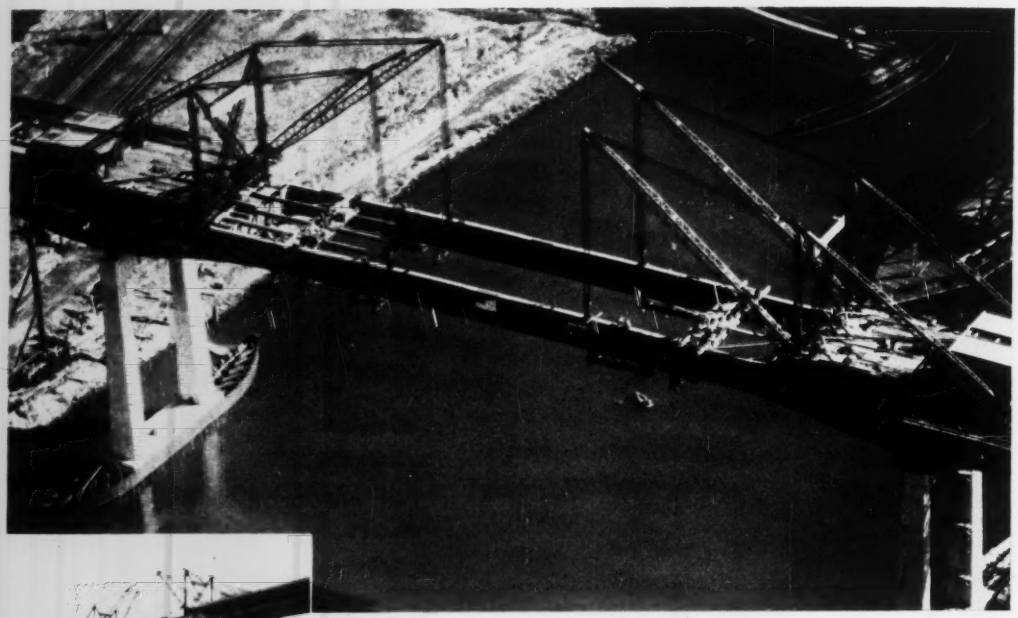
Philadelphia 3	1652—1700 Walnut St. Bldg.		
San Francisco 4	1584—200 Bush St.		
Seattle 1	1309 Henry Bldg.		
Tulsa 3	1647 Hunt Bldg.		
Washington 6, D.C.	1156 Cafritz Bldg.		

Plants in BIRMINGHAM, CHICAGO, SALT LAKE CITY and GREENVILLE, PENNA.



Aerial view of six-lane Passaic River Bridge, showing Bethlehem Steel crew fitting closing girders into place. *Owner:* New Jersey Turnpike Authority; *Chief Engineer:* Charles M. Noble; *Former Executive Director:* W. W. Wanamaker; *Consulting Engineers:* Ammann & Whitney, New York; *General Consulting Engineers:* Howard, Needles, Tammen & Bergendoff, New York.

Travelers on bridge deck, each equipped with two booms, shown raising twin 118-ft closing girders, having a combined weight of 292 tons.

One of four haunch girders, erected over main piers at night because of tide conditions. Girder is 130 ft long, 22 ft deep, weighs 174 tons.

New Jersey Turnpike Crosses Passaic River

Shown under construction, the giant Passaic River Bridge is an important link in the New Jersey Turnpike, the 118-mile limited access high speed highway traversing the state. The bridge crosses the river and twenty railroad tracks, and passes beneath the Pulaski Skyway. Over the river it has an under clearance of 110 ft from mean high water. Its approaches extend from a point south of Raymond Boulevard, in Newark, to approximately 800 ft beyond the Newark Turnpike, in Kearny.

The south approach superstructure for the Passaic River Bridge consists of nineteen simply supported deck girder spans for an overall length of 2,526 ft. The north approach superstructure has twenty-four similar spans, covering a distance of 3,055 ft.

The 1,365-ft main river portion of the bridge, also of the deck girder type, consists of five spans. Here the three interior spans are continuous over four supports, with the two extremities cantilevered to carry the two end simply-supported suspended spans.

The Passaic River Bridge has two reinforced concrete roadways, each 36 ft wide, plus a central mall and safety walks. Its 7,000-ft length and 22,000-ton superstructure make it the largest of 24 Turnpike bridges for which Bethlehem fabricated and erected the steelwork.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

FABRICATED STEEL CONSTRUCTION

SMITH Impulse Turbines

FOR HIGH HEADS, and wherever the head and water quantities available prohibit the use of reaction-type machines. Ideal for installations in remote localities because of the ease with which the completed unit may be transported. The simplicity of design, facility of operation and greater dependability remove the necessity of skilled operators and attendants. Smith's solid-cast runner design provides the additional advantages of closer spacing of buckets resulting in increased speed and consequently, a decrease in the size of the turbine unit, as well as the generator. Write for your copy of our Bulletin — "Impulse Turbines by SMITH!"

Impulse runner of *solid-cast* design, an exclusive SMITH advantage.

S. MORGAN SMITH COMPANY

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POWER *by* SMITH

PILING RENTAL SERVICE FROM FOSTER IS TURNING TURNPIKE TROUBLES TO TRIUMPHS

Along the 118-Mile New Jersey Turnpike

SERVING 17 CONTRACTORS ON ONE JOB

Foster Piling Rental Service is assuring 17 major contractors of getting their piling on the job sites in advance of work schedules. In constructing such a tremendous traffic artery, countless troubles of every nature turned up; and thus Foster was the one dependable source to turn to to obtain the exact lengths and exact sections of steel sheet piling that each job required. When "man-made" problems are continuously encountered as in this job — and when major obstacles come up such as crossing the New Jersey tidal flats, you must be able to count on prompt dependable deliveries and Foster carries the largest Rental Piling Stocks in the country — all lengths and sections — in all standard makes.

This $220,000,000 New Jersey Turnpike, consisting of two parallel roadways separated by a wide center-strip, will extend from the George Washington Bridge (which connects Jersey with Manhattan Island) to Deepwater, N. J., a distance of 118 miles. These Contractors are using Foster Rental Piling:

Brann & Stuart Company, Philadelphia, Pa.
Brookfield Construction Company, New York, N. Y.
Geo. M. Brewster & Son, Inc., Bogota, N. J.
Cayuga Foundation Corporation, New York, N. Y.
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Francis A. Canuso & Son, Philadelphia, Pa.
Franklin Contracting Company, Newark, N. J.
Grow Construction Company, Inc., New York, N. Y.
Jaggard Engineering Company, Westmont, N. J.
Linde-Griffith Construction Corporation, Newark, N. J.
Napp-Grecco Company, Newark, N. J.
P. T. Cox Construction Company, New York, N. Y.
Peerless Construction Company, New York, N. Y.
Raymond Concrete Pile Company, New York, N. Y.
S. J. Groves & Sons Company, Woodbridge, N. J.
Underpinning & Foundation Co., New York, N. Y.
Union Building & Construction Corp., Passiac, N. J.

With complete piling stocks in five nation-wide warehouses, plus numerous field stocks — Foster can service your every piling need with the exact lengths and exact sections of interlocking steel sheet piling—all makes and all types. You can always count on dependable delivery "FASTER FROM FOSTER" — and the low rental rates give you an added advantage in competitive bidding. Also available for immediate delivery from Foster: Rental Lightweight Corrugated Steel Sheet Piling, Pile Hammers and Pile Extractors.

Send for FREE PILING WALL CHART CV-1

A valuable reference guide fully illustrated with tables, diagrams —pertinent facts and figures on all standard makes (all sections) of steel sheet piling, corrugated lightweight piling, pile hammers and pile extractors.

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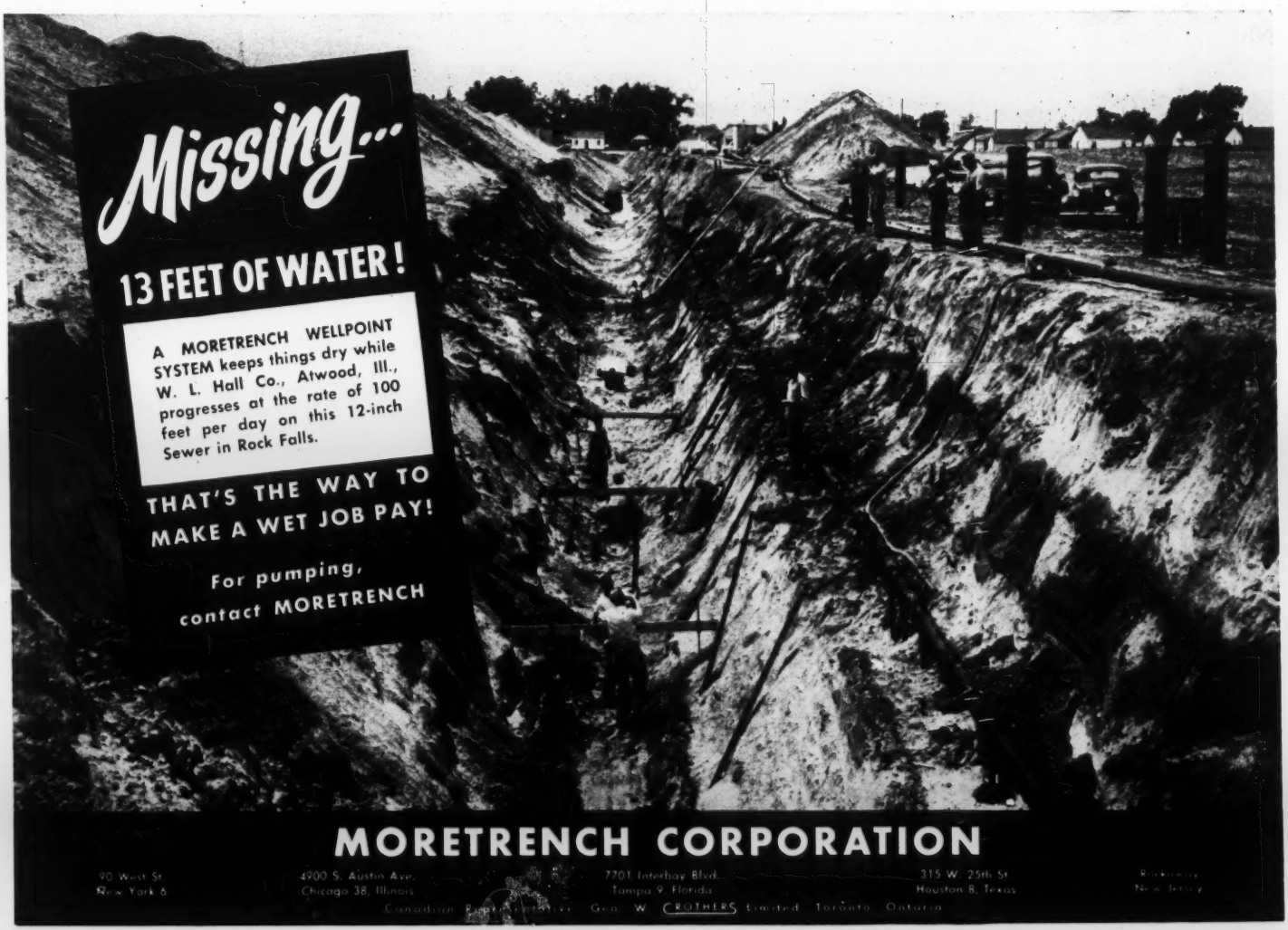
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13 FEET OF WATER!
A MORETRENCH WELLPOINT SYSTEM keeps things dry while W. L. Hall Co., Atwood, Ill., progresses at the rate of 100 feet per day on this 12-inch Sewer in Rock Falls.
THAT'S THE WAY TO MAKE A WET JOB PAY!
For pumping, contact MORETRENCH
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Keep 'em Working
in the big year coming up

MOVES MORE PAYDIRT PER DAY! That's International's Big Red TD-24—the most powerful crawler on the market—the crawler that gives you the fastest work cycle.

Here's help... where and when you need it... with your International Industrial Distributor's ready service and parts departments

Your crawler tractors have to pay off with more work done per day, more days worked per year.

That means speed and power. The ability to stay on the job. Minimum downtime.

And it also means fast maintenance service at your call, when and where you need it.

That's your International Industrial Distributor's service—service that includes

TRAINED "DIESEL DOCTORS"—factory-trained specialists in maintenance and overhaul.

PROMPT FIELD SERVICE at your job site to help keep your equipment working, to get it back to work faster, to cut costly downtime on the spot.

COMPLETE SHOP FACILITIES for major work—you're never far from an International Distributor's shop, no matter where your equipment goes.

QUICK PARTS SUPPLY from your distributor's fully stocked parts department, backed by International Harvester's network of strategically located parts depots (in size and scope, exclusive in the industry).

Isn't this *complete* service a mighty good reason to get International "*Power that Pays*" for the hard-working years ahead?

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YOU NAME IT—your International Industrial Distributor has it in his big, efficient parts department. And if he hasn't, he can get it fast from his nearby International Parts Depot.

"HEART SPECIALIST!" A crawler's heart is its sturdy fuel pump. It seldom needs attention. When it does, this "diesel doctor" operates with precision instruments in a special dust-free room.

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ON THE JOB! Here are an International Distributor's field servicemen, on the job at the job site installing an overhauled transmission. A phone call gets this kind of service.

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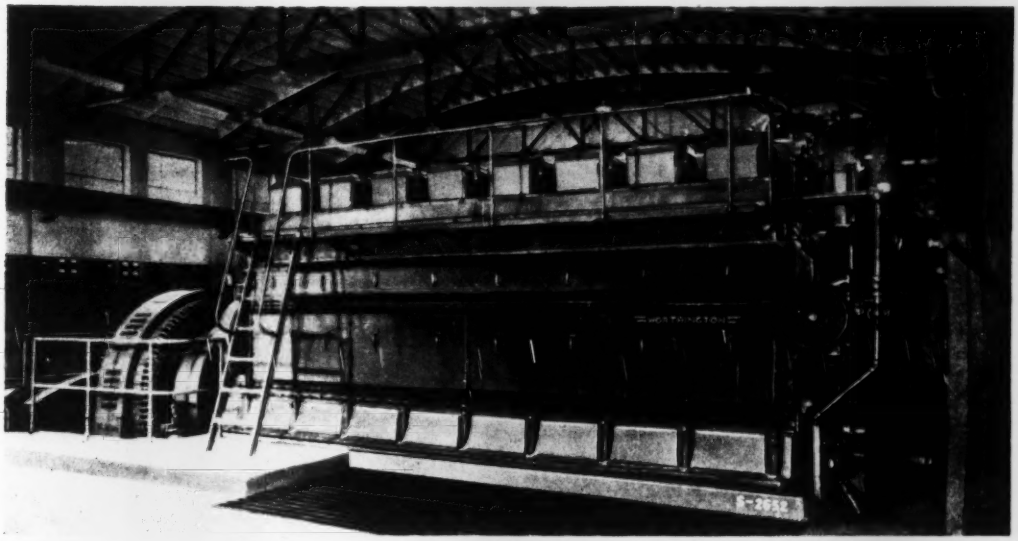
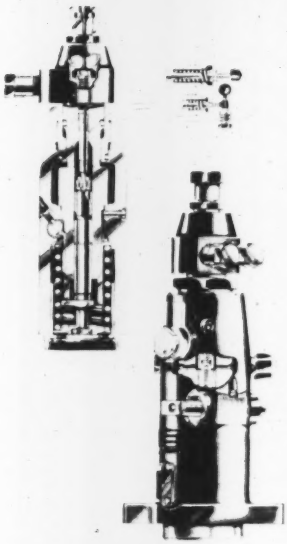


This Diesel Is Ready

FOR A CHANGE IN DIET



Worthington-designed dual plunger fuel pump.

Right now this Worthington Diesel—one of three 1760 hp units owned by the city of Tarboro, N. C.—is operating on oil.

But they anticipate natural gas in this area, and this Diesel is ready for it. With slight changes, it can easily be converted.

Worthington-designed dual plunger pumps now completely fuel this engine with oil—producing more perfect atomization, making possible the use of a *heavier* grade of oil. Also: firing pressures are reduced, exhaust temperatures, too, and combustion is improved.

When the conversion to gas is made, the dual plunger pumps will furnish pilot oil for ignition. Conversion is made quickly and at low cost.

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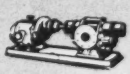

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Evaporative Type Engine Water Coolers

What every highway engineer should know about the Maryland Test Road

Not a single structural crack developed in any of the 28 forty-foot concrete slabs built on non-pumping, granular subbase

The Maryland Test Road, 1.1 miles long on U. S. 301, was a two-lane concrete pavement of 9"–7"–9" section. When it was built in 1941 pumping had not become a problem. Consequently most of the concrete pavement was placed directly on the natural fine-grained subgrade. However there was a non-pumping, granular subbase under 28 forty-foot slabs.

For nine years the pavement in this test section carried all normal traffic *plus* the heavy wartime traffic. Then for six months the pavement was subjected to accelerated truck traffic equivalent to at least 20 years of normal traffic on this road. Yet the 28 slabs on granular subbase carried 238,000 trips by trucks with single axle loads of 18,000 lb. in one section and 22,400 lb. in another section without any structural cracks. These slabs are in as good condition as when opened to traffic.

Since the Maryland Test Road was built a decade ago there have been many improvements in concrete pavement design and construction. With today's knowledge of soils, highway engineers can determine subgrade bearing values and any tendency of soils to pump. A thin insulating layer of granular material, where needed, will prevent pumping.

Thus the engineer can design a concrete pavement that will give unexcelled service under an unlimited number of legal axle loads and render this service at **lower annual cost** *than any other pavement.*

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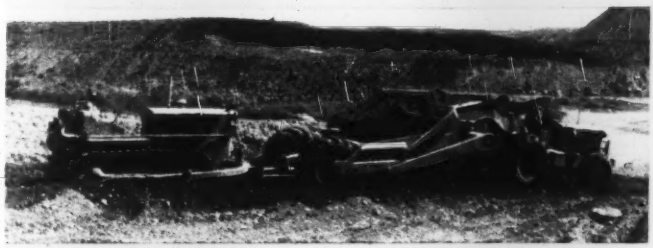
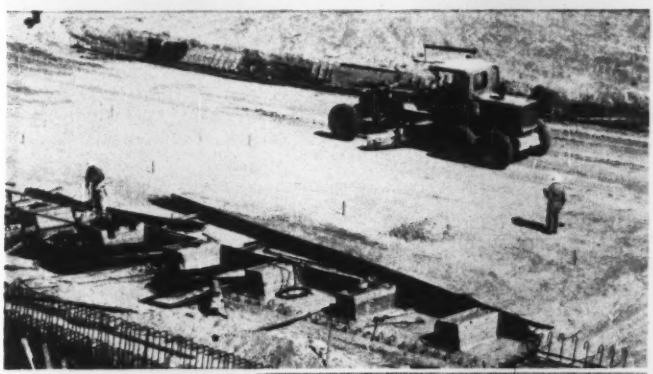
Pitching 20-hour days for Morrison-Knudsen on Snake River Dam



Push-loaded by a "Cat" D8 Tractor, this "Cat" DW20 with No. 20 Scraper averages 14 trips per hour on a 1,260-ft. round trip. Average load—17 loose yards. Working day—20 hours.



With proper balance between speed, weight and horsepower, this "Cat" No. 12 Motor Grader puts out extra production at low cost.

Steady, dependable power for this Manitowoc crane with 140-ft. boom is furnished by its "Cat" D397 Engine.

The Idaho Power Company's C. J. Strike Hydroelectric project, located on the Snake River near Mountain Home, Idaho, is scheduled for completion this summer. Its earth fill dam will be 3,220 feet long, 115 feet high, 675 feet wide at the base and 30 feet wide at the top. It will contain nearly 2,000,000 cubic yards of material.

Morrison-Knudsen Company, general contractors for the development, are making good use of "Caterpillar" equipment to keep on schedule. Among the "Caterpillar" machines on their roster are a DW20 wheel-type Tractor with No. 20 Scraper, a D8 track-type Tractor with 'Dozer and a No. 12 Motor Grader. Powering a Manitowoc crane with 140-ft. boom is a "Cat" D397 Engine.

Glenn C. Johnson, Morrison-Knudsen Superintendent, keeps a close check on the performance of all his equipment. The high-speed, new "Cat" DW20 is proving itself a big producer. With the D8 push-loading, the DW20 averages 280 trips per 20-hour day on a 1,260-ft. round-trip haul. Average load per trip is 17 pay yards—a total of some 4,760 pay yards per day. Like all "Caterpillar" equipment, sturdily built to stand up under tough going, the DW20 stays on the job with a minimum of down-time.

Many contractors have found that standardization on "Caterpillar" equipment pays off in more ways than schedule-keeping performance. There's also a simplification of their service and maintenance problems that saves time and money. One dealer, the dependable "Caterpillar" Dealer, has the know-how and facilities to take care of the entire "Caterpillar" line of tractors, motor graders, engines and earthmoving equipment. By having him make regular inspections and authorizing him to recondition parts before they become unusable, contractors find they can add many extra working hours to the life of this sturdy equipment.

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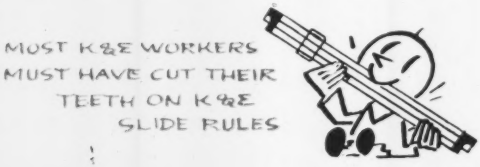
Precision in the Air

I've been talking about K&E products for a long, long time. Maybe it's time I talked a little about the people behind them.

I've just been through the K&E factory at Hoboken again. I wish you could have been along, because you, as an engineer, would have seen much more than I. But even I could sense the honest craftsmanship and the father-and-son tradition of precision and the zeal for quality in the air.

You just don't get to be that fine in one generation.

There are a number of K&E employees who have been around for about a half a century, and there are some 150 employees who have been there for a quarter of a century or more. This latter bunch of kids, as well as the young sprouts who have been there only 20 or 15 years, have inherited the K&E feeling for doing things the good, old, exciting, honest way.



But don't get the idea that there is any moss on K&E. An outfit that has thrived this long has to have the knack of remaining perennially young and of keeping ahead of the pack.

The first factory built by Keuffel & Esser, in 1880.

"Partners in Creating"

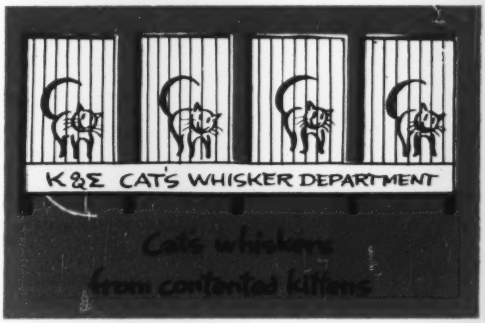
When K&E coined the phrase "Partners in Creating," they of course meant not themselves but their products. And it's true that K&E products have been in with engineers, scientists, draftsmen and architects on the

The K&E trade mark for decades, and the more modern one adopted in recent years.

creation of most of the big man-built wonders of the world for over 4/5 of a century.

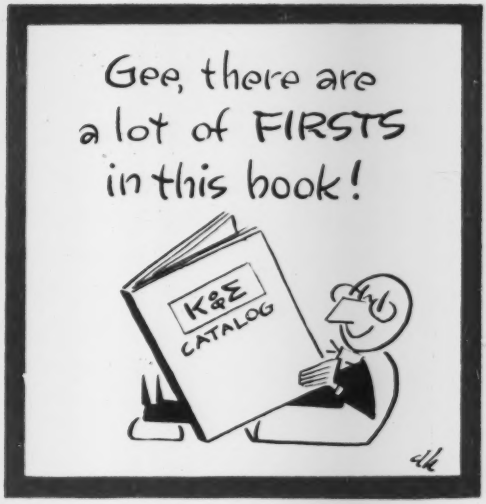
Zippy at 84

K&E have remained alert and alive, as is evidenced by their unending originality and inventiveness. They made America's first slide rules, as far back as 1891. And in both world wars, they did a big development job on optical equipment for our fighting men—on vital things such as periscopes, fire control instruments and height finders. The K&E catalog is full of "firsts"—some of them plenty recent, such as Wyteface* Measuring Tapes and Leroy† Lettering Equipment. No wonder it's the engineers' encyclopedia.



Factories within a Factory

K&E headquarters are a town within a town, many factories within a factory. In one area they're coating miles of papers and cloths. In another they're turning screws so tiny you feel like a hippopotamus if you try to pick one up. Here they're grinding optical lenses.



There they're putting graduations no bigger than a fly's kneecap on scales of some sort. Here they're doing fastidiously fine leather work. There they're reeling off steel measuring tapes by the mile.

K&E was in there sighting, in World Wars I and II

But wherever you go you are aware of the age-old passion for precision and quality. And I'm not the least bit sorry that today I haven't sold you a single K&E product. I've just tried a little bit to sell you on the people at K&E—and to get you to believe that you can safely make K&E products trusted partners in your own creative work.

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*Reg. U. S. Pat. Off.

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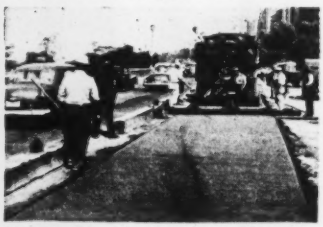

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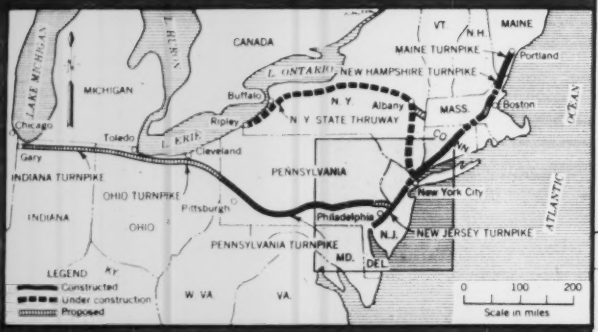
NEW JERSEY TURNPIKE

TOMORROW'S HIGHWAY BUILT TODAY

With completion this month of the $255,000,000 New Jersey Turnpike, motor vehicles can travel for 118 miles at an even 60 miles an hour from New York's George Washington Bridge southwest across New Jersey to the new Delaware Memorial Bridge near Wilmington, Del. Because the route cuts through one of the most densely populated and heavily industrialized areas in the country, right-of-way costs were high and engineering problems were aggravated. Financed by revenue bonds without federal or state aid, this toll expressway is self-liquidating. Seven engineering firms were made responsible for its design and supervision of construction, one for each of the construction sections. The first of the more than 80 major construction contracts was awarded in December 1949. The 50 different prime contractors used equipment with a total value of $45,000,000. Simultaneous operations on all sections and an accelerated schedule led to the opening of the southern 93 miles in November 1951, in the record time of 23 months. Top engineering talent has built long life, safety, and public convenience into the Turnpike—it has been characterized as "tomorrow's highway built today." It is a worthy monument to the 700 engineers and 10,000 others who toiled to design and build it.



THE STORY of the New Jersey Turnpike, told in the following pages, originally was presented during the ASCE Annual Convention in New York, at sessions jointly sponsored by five of the Technical Divisions (Construction, Engineering Economics Highway, Soil Mechanics and Foundations, and Structural), with Elmer K. Timby, M.ASCE, then chairman of the Executive Committee of the Construction Division, presiding at the opening session.

New Jersey—A Traffic Corridor

PAUL L. TROAST
Chairman, New Jersey Turnpike Authority

Limited-access Turnpike relieves congestion

ANY DISCUSSION of the New Jersey Turnpike and the New Jersey Turnpike Authority can appropriately begin only with a tribute to the very able governor of New Jersey, the Hon. Alfred E. Driscoll. Realizing as far back as 1946 that extraordinary measures would be required to cope with the ever-increasing problem of vehicular traffic in New Jersey, Governor Driscoll sponsored the legislation authorizing the New Jersey Turnpike Authority. He stayed with the enabling act, saw it through the legislature in 1948, and finally, on March 31, 1949, only some thirty short months ago, appointed the three members of the Turnpike Authority.

He was of inestimable help during the entire period in which my colleagues and I struggled with the many problems involved in building any major highway, and particularly in building a limited-access express highway through the northern part of New Jersey, where communities border on one another, where space is at a premium, and where cost is a very serious consideration.

Geographically New Jersey is one of the smallest states, but in terms of population and of importance to the economy of the country it is one of the greatest states. As a result of its location, it has a concentration of traffic the like of which does not exist anywhere else in the United States, or in fact, anywhere else in the world. It is a corridor lying between the populous areas of New England and New York, Pennsylvania, the South and the West. In addition, it is the connecting route between New York and Philadelphia, the first and third largest cities in the country. Thus we have the serious problem of routing through transportation as well as the local problem of handling the vehicular traffic of our own state.

The state has only limited means with which to solve these traffic problems. The State Highway Department, for instance, has only some $30,000,000 a year available for new state highway construction. To point out that parts of the New Jersey

Turnpike, particularly in the northern section of the state, cost as much as $8,000,000 per mile, probably emphasizes my point better than anything else I could say. Under the circumstances the financing of a project such as the Turnpike could obviously not be accomplished in any ordinary way. It was Governor Driscoll who had the vision to realize this fact.

New Jersey has not always had the traffic problem that confronts it today. At the end of World War I it was one of the leading states in highway construction. In the period following the war it built the Pulaski Skyway, the Jersey City open cut, and a major part of the dual highway mileage in the entire United States. Then came the depression with its curtailed construction and, after that, World War II, with shortages of materials, money and labor. A year or two ago it was estimated that New Jersey needed an expenditure of $600,000,000 to bring its state highway system up to date and enable it to cope with the extraordinary traffic conditions that had arisen.

The foregoing situation, it must be remembered, was prior to the price-inflation spiral brought about by the Korean War. Even with the Turnpike practically a reality at an expenditure of $255,000,000, present estimates would have to place the state's new highway construction needs at nearly a billion dollars.

A review of what happened to the facilities serving New Jersey in the thirty-month period between the end of 1947 and July 1, 1950, will be illuminating to those not familiar with the New Jersey traffic situation. These important facilities serving the state include the Port of New York Authority's three Hudson River crossings—the George Washington Bridge, the Holland Tunnel, and the Lincoln Tunnel; the Pennsville Ferry, recently replaced by the Delaware Memorial Bridge; the Philadelphia-Camden Bridge; and the Edison Bridge serving our shore traffic. In the thirty months in question, traffic on each one of these facilities increased from 36 to 43 percent, the rate of increase on the major facilities being the higher percentage.

Today the traffic volume on Route 1, opposite Newark Airport, is in excess of 100,000 vehicles a day. In the narrow nine-mile corridor between the Orange Mountains and Newark Bay, north-south traffic amounts to more than 300,000 vehicles a day. In a recent check-up on some of the facilities showing a 43 percent increase in the thirty-month period up to July 1, 1950, it was found that although the three trans-Hudson crossings of the Port of New York Authority had a record of some 53,000,000 crossings in 1950, the 1951 rate was 17 percent in excess of that record year.

Such considerations as these will give an idea of why the New Jersey Turnpike had to be built as a toll and revenue-bond project. For the benefit of those who are interested in how we went about determining whether a toll project was required, and then how we proceeded on a policy-making level, I will review the steps preliminary to bringing the Turnpike into being.

Turnpike Authority Is Set Up

As I have said before, the New Jersey Turnpike Authority has been in existence only thirty months. In the first two months three of us—businessmen without any political experience, or any experience, in building highways or bridges—were tapped on the shoulder by the Governor and told, "You're it." It took us two months to make the initial studies required to determine whether we should recommend any toll projects for the state and to assemble a small, competent organization to aid us in these studies.

By the end of two months we were satisfied that a major backbone highway was an immediate necessity. We had determined that the highway should extend from the George Washington Bridge, southerly across the State of New Jersey, to the Pennsville Ferry, now the Delaware Memorial Bridge. We had also determined that it should be adjacent to all the major centers of population in the state, including such cities as Newark, New Brunswick, Elizabeth, Trenton, Camden, and others south to Deepwater, and the populous areas of Bergen, Hudson, and Passaic counties adjacent to its northern terminus.

Consulting engineers and engineering firms were then employed to make over-all recommendations as to alignment and cost estimates, and other experts to determine traffic and revenue figures. They were given a short four months to make the study—a study that was to be the sole basis of our request to the revenue bond market for some $255,000,000, as it eventually turned out. It is much to the credit of the engineering firms in question that they were able to complete the study so quickly. However, it was another five months before we actually had the money both in hand and committed.

The reason for the delay was that there was found on the statute books a case involving a similar authority but concerned with water, which had been held unconstitutional by our highest court. It was thus necessary for us to test the constitutionality of the New Jersey Turnpike Authority Act. We had also to find out when we requested funds, whether legislation giving us certain needed additional powers could also be obtained. So it was eleven months from the time we were first appointed an agency of the State of New Jersey to the time funds were available.

To avoid delay we jumped the gun a little by hiring engineers to start the design of the project before there was money to pay them. We had others preparing maps so that as soon as we were in receipt of funds we could begin to acquire the 3,400 parcels of real estate needed for the New Jersey Turnpike. After consultation with the engineers, we then set ourselves a goal of 22 months from the time we received the funds to completion of the project. This goal was contingent on getting the paving done in one construction season. It was a case either of completing it in November 1951 or of going into the midsummer or fall of 1952.

Once again I must pay tribute to the engineers, whose cooperation has permitted the successful outcome of every phase of the project in record time. Involved in the Turnpike work was the moving of nearly 52,000,000 cu yd of earth; the building of 260-odd structures, five of them major bridges; and the laying of almost 7,000,000 sq yd of pavement, including the shoulders. We have obtained since the beginning of the Korean War—and it should be remembered that of our twenty or twenty-one months on the project, only four months were before Korea—a total of 191,000 tons of steel of all kinds.

Tribute must also be paid to the very able Turnpike Authority staff. For the first eleven months of the work, before funds were available, we functioned with only ten paid employees. At the beginning of 1951, with some $200,000,000 worth of construction under way, we had a total of 82 on the payroll. The work was accomplished by utilizing private real estate experts and firms and private engineers as consultants and section supervisors. Finally tribute is due the top-level executives on the Turnpike Authority—W. W. Wanamaker, M. ASCE, our Executive Director, and Charles M. Noble, M. ASCE, our Chief Engineer.

NEW JERSEY TURNPIKE

W. W. WANAMAKER, M. ASCE
Executive Director, New Jersey Turnpike Authority
Trenton, N.J.

Streamlined staff directs big project

A FEW non technical and personal comments on the organization and procedures of the New Jersey Turnpike Authority will give a closer understanding of the methods employed during the past two and one-half years to bring about the practical completion of a remarkable project.

The staff of the Authority includes a counsel, a comptroller, a chief engineer, a director of real estate, and a director of public relations. So closely associated with us as to be in effect a part of our immediate staff, are our consulting engineers, the firm of Howard, Needles, Tammen & Bergendoff. When I joined the Authority, there were 17 employees; we have now grown to about 90. The members of the staff were unknown to each other when they were first employed, although each was a specialist in his own particular field.

The three commissioners, who have served without pay, have met regularly once a week since their appointment in March 1949. Beginning shortly after 9 a.m., these sessions always lasted well into the late afternoon, and frequently into the evening, with no time out for luncheon except sandwiches eaten at the conference table. Each of these meetings has been attended by the principal members of the Authority staff and by the consulting engineer. A comprehensive agenda including exhibits, charts, and weekly reports of progress, prepared in advance of each meeting by the executive director, afforded the commissioners opportunity for study prior to the date of the meeting. Each feature of the project was covered at each meeting, including design, construction, real estate acquisition, special problems, finances, administration and personnel, and general planning for the future. At many meetings the engineers for the particular sections involved and members of their staff and the consulting architect's staff were present for specific presentations and discussions. Several meetings were attended by the Special Paving Committee to give the commissioners an opportunity to review all the committee's design criteria, assumptions and conclusions.

Staff Functions Described

The staff had its work cut out for it, and as the sessions continued, the work was repeatedly redefined and reemphasized so that no one could misunderstand his respective obligations. If my somewhat bantering comments will not be taken too literally, I might describe our functions as follows: To speed up progress; obtain perfect construction methods and procedures; procure the country's best contractors in competitive bidding at prices below engineers' estimates; construct the finest turnpike ever devised and, at the same time, issue only such change orders or modifications of plans as would reduce costs and improve quality; acquire the right-of-way for the 118 miles in nothing flat; pay no more than fair market value but satisfy fully all property owners; resort to condemnation where necessary, but avoid the possible criticism that land owners were being robbed by a high-handed Authority; satisfy each of the ten counties through which the Turnpike passes, and their respective townships, boroughs, and municipalities in providing improvements and betterments in constructing crossings over or under the Turnpike, without increasing over-all costs to the Authority; procure steel, copper, and other critical materials without delay, regardless of what the National Production Authority might have to say; see to it that all roads damaged in construction were repaired, no matter by whom the damage was done; satisfy in some manner those interested in employment; and finally, lay down an asphaltic concrete pavement and convince the cement people that it was a good decision.

In all seriousness, however, with the host of engineers engaged for design and supervision of construction, there was a real problem of coordination and the need for exact definition of responsibilities. At the peak of the construction period this past summer, when we had under way nearly 80 major construction contracts, involving close to $200,000,000 worth of work, and were faced with the cumulative effect of delays due to critical material and manpower shortages, it seemed at one time almost a certainty that the job could not come out on or even close to schedule. In such circumstances there was the natural tendency to tighten control—that is, to centralize operations in Trenton completely. That, however, was thought not to be the answer. In the manner of a well-trained football team which, when ground gaining is tough, opens up its play, not in desperation, but in order to afford each of its eleven members full opportunity to give the best they have, we in great measure put responsibilities more directly in the hands of our section engineers, with such delegation of authority as was essential to expedite progress. All have come through in fine fashion.

Seven Sections for Construction

The Office of Chief Engineer was established to obtain direct engineering advice for the coordination of design and establishment of specific design criteria, and for general over-all supervision of the construction assigned to the consulting engineer and to the section engineers. To expedite design and the initiation of construction, the Authority divided the 118-mile Turnpike into seven sections and assigned a nationally recognized highway and bridge en-

gineering firm to design and supervise construction within each section. These selections and assignments are given in the box on the following page.

During the first year of construction, the chief engineer had as his immediate assistant a construction engineer, who in turn had three area engineers as assistants. With expansion of construction, it became apparent that there were ambiguities in the assignment of duties and responsibilities, and at times it was difficult to determine the exact functions and duties of the assistants to the chief engineer, of the section engineers and their resident engineers, and of the consulting engineer, who had his own staff of specialists. This led finally to the abolition of the area engineers, a more direct delegation of authority to the section engineers, and the assignment of a representative of the consulting engineer in the offices of the Authority, so that the combined advice of the chief engineer and the consulting engineer would be continually and currently available. This procedure aided in resolving more rapidly the many different views that are naturally found in a large staff of engineers, not only concerning construction problems, but on such matters as the priority of importance of construction items, and the design and construction of concession areas, signs and highway markings, toll plazas, the toll collection system, and other problems of both initial construction and final operation.

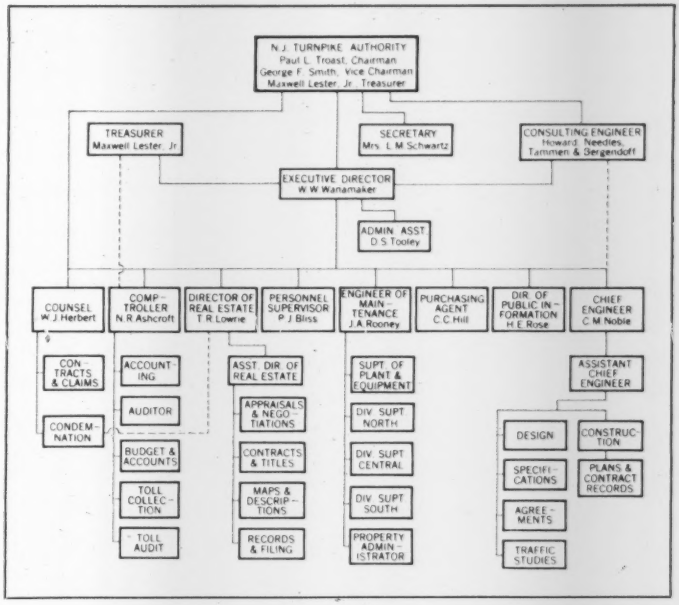
The maximum rate of progress and expenditure was reached in August, September, and October 1951, in which three months more than $50,000,000, or about 25 percent of the entire construction cost, was paid out. During this period all contractors were urged to work at peak capacity, with full use of overtime and six- and even seven-day work weeks to meet the construction schedule. The period called for a high degree of coordination among the engineers and contractors, broad delegations of authority, quick decisions, and an all-out effort to exhaust every source of labor and materials. It was in this period that a "streamlined" organization was imperative.

Financial Setup Devised

The trustee of the Authority is the Chase National Bank of New York City, which handles all the Authority's funds. Requisitions are made on the bank as required to pay contractors, engineers, property owners, and others. These requisitions were submitted almost daily during the peak construction period, reaching a high mark of $22,260,000 in October 1951. Promptly upon receipt of a requisition from the comptroller, signed by the consulting engineer, and in the case of land acquisition, by counsel as well, the trustee transferred from the construction fund to the credit of a special account in the name of the Authority the total amount set forth in the requisition. When advised by telephone that such a transfer had been made, the comptroller drew checks for payment of the various accounts included in the requisition, which were signed by the executive director, who is also the assistant treasurer.

The major construction contracts were assigned different dates for the submission of monthly pay estimates so as to equalize the work load of field engineers, computers, and staff officials in the preparation and certification of these estimates over the month, rather than to impose an undue load upon them at the end of each month. This procedure, coupled with the dual capacity of the executive director, has speeded up payments greatly. Many contractors have complimented the Authority on its prompt payment, which normally required only a few days from receipt of the pay estimate by the chief engineer.

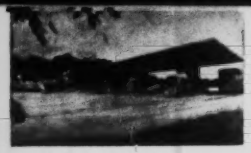
The Authority's bond resolution also authorized the establishment of a revolving fund in the maximum amount of $200,000, which was available directly to the Authority for meeting its payroll and other operating costs. This avoided making individual and numerous requisitions on the trustee for comparatively small amounts.



Acquisition of Real Estate Difficult

One of the most difficult and complicated problems facing the Authority in 1950 was the acquisition of some 3,400 parcels of real estate required for the Turnpike right-of-way. Each of the section engineers was responsible for the preparation of property maps defining the lands to be acquired. Although the initial drawings showing the general location were prepared by the end of 1949, a great many modifications and adjustments, including such requirements as slopes and drainage easements, interchange and service areas, were not finally determined upon, in some instances, until late in the fall of 1950.

Property drawings were prepared by licensed New Jersey surveyors, working under the supervision of the consulting engineers of each section. The director of real estate initiated early in 1950 a screening of candidates to act as local appraisers and negotiators for the ten counties traversed by the Turnpike. The selection of the first appraiser



was approved on February 10, 1950, and the first contract for the employment of real estate personnel was approved early in March of that year.

It was neither possible nor desirable for the Authority to engage on its immediate staff the number and type of experts required because of the short duration of employment and the difficulty of obtaining such experts on a full-time basis. On the other hand, it was obvious that the Authority must have under the director of real estate an adequate number of independent experts to appraise and review the results of the field activities in order to prevent distortion of values or faulty negotiations.

Summary of Real Estate Organization

The organization to carry out these functions may be summarized as follows:

1. A director of real estate with a small staff of specialists, plus the necessary clerical and legal administrative help, all on a full-time basis and directly employed by the Authority.

2. Local appraisers reaching a total of 30 firms and individuals at the peak.

3. A staff of negotiators, reaching a total of 66 firms and individuals paid mainly on a "perparcel" basis.

4. A group of specialists for the appraisal of highly industrial properties.

5. County real estate supervisors who acted as general supervisors of the appraisers and negotiators, often carrying out the final negotiations, and who were paid generally on a monthly basis of compensation.

The total cost of the real estate acquired or in process of acquisition is approximately $18,000,000. In spite of a late start, it was possible by means of voluntary rights of entry procured from landowners to keep ahead of the contractors, or at least to avoid crippling delays.

Permanent Headquarters and Staff

After a thorough study of the question of a permanent administration building, it was decided to construct one at the site of the interchange at New Brunswick. The building, which will be owned and occupied solely by the Authority, will be located on a triangular-shaped area procured largely for the interchange. Central location of the building along the Turnpike will permit handling problems relating to maintenance and the collection of revenues. It is excellently situated in relation to access from the Turnpike, from other highways and the railroad, and affords other conveniences to employees and visitors.

The staff was expanded gradually over the two-year period of construction, and at this time has attained the proportions indicated on the chart (page 29). It is indeed remarkable that an undertaking of the magnitude and complexity of the Turnpike could have been directed and coordinated by such a small organization. The key personnel remained few in number, and were required to devote unusual effort and to work long hours to keep pace with expanding activities. The organization is now being considerably expanded as a result of the employment of operating and maintenance personnel, and for the transition from construction to operation. There are being added to the payroll approximately 150 toll collectors and associated employees, and about 200 for the maintenance forces. The size of the latter force is dictated largely by the personnel necessary to keep the Turnpike free of snow and ice during winter weather.

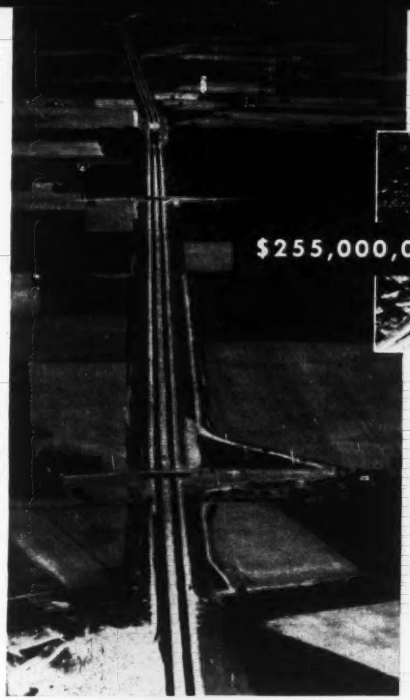
Aside from the outstanding work of the eight engineering firms (see box at bottom of page) and the two architectural firms who planned and supervised the construction of the Turnpike, and to whom great credit must be given, the successful completion of the project will be due to the efforts of two other groups—one very small and the other very large.

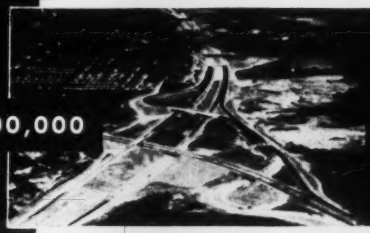
The first comprises a group of three men: The Chairman, the builder, a man of relentless drive, resourcefulness, energy and vision, who gets to the heart of problems with astounding speed and directness, who gets things done without running roughshod over anyone; the Vice-Chairman, the business executive, a man of brilliant mind with intense public interest, direct, concise, and to the point, one who has brought to the Authority a wealth of business experience, who has guided us at all times in operating in accordance with sound business procedures; and the Treasurer, a big man both physically and in his viewpoint, skilled in the financial field, with an almost uncanny ability to detect danger spots, and the wisdom to steer us through or around them. The Governor should have the enduring gratitude of the state for the selection of three such men. Aside from our organization chart, and its statements of functions, duties, and operating procedures, the reason for our progress is to be found pretty much in these three men.

The second group comprises the 10,000 or more workers who actually built the Turnpike—the contractors and their superintendents, foremen and workers. The Turnpike stands as a worthy tribute to the skill and resourcefulness of the construction industry, to American methods of private enterprise, and as a fitting memorial to the unfortunate few who lost their lives in its construction.

Engineering Firms Selected as Section Engineers to Design and Supervise Construction

Section	Location	Firm	Work	Length, Miles
1	Deepwater to Woodbury	J. E. Greiner & Co.	Highway & bridges	20.2
2	Woodbury to N.J. Route 38	Gannett, Fleming, Coddrin & Carpenter, Inc.	Highway & bridges	17.8
3	Route 38 to Hightstown	Parsons, Brinckerhoff, Hall & Macdonald	Highway & bridges	21.7
4	Hightstown to Raritan River	DeLeuw, Cather & Co.	Highway & bridges	24.5
5	Raritan River to Morse's Creek	Fay, Spofford & Thorndike	Highway & bridges	14.3
6	Morse's Creek to Bellville Turnpike	Ammann & Whitney	Bridges	10.5
7	Bellville Turnpike to Route 6	Howard, Needles, Tammen & Bergendoff	Bridges	8.6
6-7	Morse's Creek to Route 6	Edwards & Kelcey, Frederic R. Harris, Inc., O. J. Porter & Co.	Highway	





ENOCH R. NEEDLES

M. ASCE

Consulting Engineer
New York, N. Y.

ACROSS New Jersey's farm lands and industrial areas stretches 118 miles of modern highway with no crossings at grade. Entire project was built without state funds.

Revenue bonds build 118-mile expressway

without federal or state aid, subsidy, or obligation

A NECESSARY preliminary to construction of the Turnpike was to demonstrate its economic feasibility to the extent that the revenue to be derived from tolls would be adequate to support construction and other project costs on an investment basis. Since funds for the project were to be obtained only from the sale of revenue bonds to private investors, the usual rigorous tests for securities of this character had to be met. The primary purpose of this article is to discuss the development of construction costs and other expenditures that make up the total project cost. These figures appear in the comprehensive engineering report upon which the financing had to be based.

We engineers believe that construction of any state or public highway should be justified by its use and its service to the public rather than by political expediency. Consideration should also be given to the general good which will result from the building of a highway. The development of the nation was a primary consideration in the building of our highways in Colonial days, and today it is the basis of our extensive and important federal aid to highways. The New Jersey Turnpike, however, like other revenue bond projects, had to be justified not on the basis of use or general good alone but also on the basis of its direct financial return—an investment basis. How many of our highways would be able to meet this severe test in order to have their construction justified?

Turnpike Is Economically Feasible

The New Jersey Turnpike meets every test as to broad justification and financial feasibility. It required no promotion. It came about as the result of necessity. In fact, I know of no publicly owned toll highway that has been built except on the grounds of necessity. Governor Alfred E. Driscoll of New Jersey first realized the full necessity of building the Turnpike as a toll highway, and he was the driving force behind the legislation, the setting up of the Authority, the preliminary arrangements, and the action required to complete the project quickly.

The members of the New Jersey Turnpike Authority were appointed in the spring of 1949. The preliminary studies and reports were completed and financing arranged within about ten months, and actual construction started in the spring of 1950. Completion before the end of 1951 just about establishes a record for the execution of a very complex highway project 118 miles in length and costing $255,000,000. The remarkably high character and ability of the non-salaried Commissioners of the Authority has considerable bearing on the successful outcome of the project.

For several years prior to 1949, New Jersey highway officials realized the need for bold planning regarding major traffic arteries to solve the highway problems of the state. Route 100 was conceived as an expressway connecting the New Castle-Pennsville Ferry over the Delaware River, in the southern part of the state, with the George Washington Bridge over the Hudson River in the northern part. Route 4 Parkway, now the Garden State Parkway, was conceived as connecting the populous suburban areas of north Jersey with the Atlantic seaboard communities from Sea Bright to Cape May.

In June 1948 the State of Delaware began building the $45,000,000 Delaware Memorial Bridge to replace the New Castle-Pennsville Ferry. It is of interest that the Delaware authorities financed and started construction of the Delaware Memorial Bridge without any thought that the New Jersey Turnpike would come into being and connect with its eastern terminus. In fact, they had no information as to when New Jersey Route 100 would be built and connected with the bridge. After con-

struction of the Delaware Memorial Bridge had started, Governor Driscoll realized the imperative need for a new traffic artery in New Jersey, and it was then that the New Jersey Turnpike took the place of the proposed Route 100. On August 16, 1951, the Delaware Memorial Bridge was opened to traffic. The completed Turnpike is now connecting directly with it, and both facilities supplement each other to the very great benefit of the motorist.

There are many aspects of the modern "motorized" economy of these United States which conservative, factual engineers do not always readily comprehend. We are a little slow to believe and evaluate all we see. In less than six years 30,000,000 motor vehicle registrations have increased to 50,000,000. We spend more than ever for our highways but not enough to keep pace with obsolescence and deterioration. We have 1940 highways with 8,000,000 new vehicles coming onto them in 1950 alone. We see record traffic volumes and congestion and scarcely dare to evaluate them factually.

Not long before the Delaware Memorial Bridge was completed it was necessary to estimate the number of toll lanes and toll collectors required for peak days. The peak day on the Newcastle-Pennsville Ferry had been 17,000 vehicles. At that time the cars were reported lined up two abreast for seven miles, and the story of the congestion made the front page of New York papers. It appeared that the highways leading to the bridge could not reasonably handle a great many more cars. With all that was known about previous travel movements, I attempted to prophesy the peak days of the future. With the New Jersey Turnpike not yet open, 20,000 or at most 25,000 vehicles, appeared a good guess for the peak days of August and September following completion of the bridge. Then allowing the imagination full play, I ventured that there might be one or two peak days in the summer of 1952, after the Turnpike was open, when 30,000 vehicles would use the bridge. On the first Sunday after the bridge was open, 36,000 vehicles passed over it. Within its first 20 days of service there were four days when it carried approximately 30,000 vehicles or better, and the Turnpike was not yet in use.

The traffic studies for the New Jersey Turnpike were exhaustive and factual, consistent with the needs for financing. Not much time will pass before the Turnpike traffic will materially exceed the estimates, and there will be peak loads that will completely tax its facilities. At the same time fullest use of the Turnpike will be restricted by the limited capacity of the approach highways connecting with it. For 25 years I have observed the building of New Jersey highways. Without exception, each new artery that has been built has become overloaded almost as soon as it was opened.

Turnpike Held Vital to Defense

An investment banker recently asked what would happen to the Turnpike traffic in the event of a national emergency and gas rationing. Gas rationing and greatly reduced traffic might become a fairly serious matter on a revenue bond project. However, in a national emergency, our industrial activity must be expanded to the fullest. Since the New Jersey Turnpike passes through the most heavily industrialized areas of the state and connects other major industrial areas of the nation, it appears logical that great industrial activity would produce very heavy essential traffic on the Turnpike, both passenger vehicles and trucks. In addition, if an emergency produces military traffic, beyond question the Turnpike will serve as one of the most vital military routes along the entire Atlantic coast.

Another investment banker asked about the permanence of the New Jersey Turnpike construction and particularly about the life of the pavement and its adequacy for heavy loads. The quality of construction is the highest that modern research, engineering design and construction methods and equipment can produce economically. The structures will of course last indefinitely. Now as to the embankments, drainage and pavements. Compacted embankments surmounted by frost-free materials form a permanent and stable foundation on which to build the pavement. Thorough drainage will eliminate trouble from excessive moisture.

The only vulnerable part of the pavement, then, is the wearing surface itself. A pavement designed for permanence and low maintenance cost, and laid on a stable and strong foundation, will last indefinitely. Such construction is costly but justified. Witness the old Roman roads. Such construction will carry any axle load imposed through pneumatic tires.

There is no permanent wearing surface. All surfaces require maintenance and eventual reconditioning, especially if smooth, safe and superior riding surfaces are required for the user and toll payer. Normal maintenance during the early years of any modern heavy-duty pavement should be very low, whether the wearing surface is of asphaltic concrete or portland cement concrete. Actual records of maintenance on the Main Turnpike pavement during the first four years of service show a total cost of about $12,000 for some 47 miles of four-lane highway. This amounts to $64 per mile per year for four lanes, and there is no indication that the cost will soon be increased materially.

Future Reconditioning

To be conservative, we may assume that in about 20 years or so the New Jersey Turnpike pavement will need a surface reconditioning, or "face-lifting," throughout its length, in order to continue providing a superior riding surface. The cost of a thorough "face-lifting" job should not exceed the earnings of the Turnpike for a four- to six-month period, and the net effect of such a job, if it becomes necessary, will merely be to extend the amortization of the revenue bonds by a four- to six-month period.

The foregoing gives an indication of the basic thinking that entered into the conception and design of the New Jersey Turnpike. In May 1949, work was started on the preliminary surveys and studies which resulted in a completed engineering report, adequate to support financing by September 1949, a period of about four and one-half months.

The Authority members held meetings with Spencer Miller, then Highway Commissioner for the State of New Jersey, and with Charles M. Noble, M. ASCE, Chief Engineer of the Highway Department, and shortly thereafter to become Chief Engineer for the Turnpike Authority. To expedite the work, the Turnpike Commissioners decided to hold their own engineering organization to a minimum and to utilize the existing organizations of several private firms. Within a short time, these firms jointly had assigned over 600 men in their organizations to the work. During the first five months, and before the bonds were sold, the Turnpike Authority expended over $600,000 on the development of the project. These figures give some idea of the magnitude of the preliminary work and the speed and labor that

went into the preparation of the engineering and traffic reports which were necessary to demonstrate financial feasibility.

Good Maps Expedite Turnpike Planning

New Jersey fortunately is well mapped. State highway maps, county and city maps, and land maps are unusual in their completeness and detail. These were utilized very fully by the engineers. Aerial photographs were also available and were used to some extent, but a complete new aerial survey with contour mapping was early ruled out as being unnecessary and too time-consuming in view of the excellent maps already available. Local engineering firms within the state were consulted very extensively on location and land surveys. Data in the state departments pertaining to geology, water resources and drainage conditions were utilized fully, and the knowledge and advice of state as well as local officials were sought.

Location studies were begun immediately, both by map study and field reconnaissance. Traffic movements that would affect Turnpike location were studied with the traffic engineers. Services to be rendered to the larger communities were also fully studied. Field surveys were started on the preferred routes, and alternate routes were extensively surveyed. As soon as such studies were completed for portions of the route, alignment and profiles were established and borings and other foundation explorations and soil investigations started. Data were gathered to determine navigation and waterway clearances for bridges, and steps were taken to settle these clearances as fully as possible with federal and state authorities so that initial bridge designs could be undertaken. Conferences began between the engineer principals to determine suitable standards for layout, design and estimating. Surveys were made as to the availability of construction materials and contracting organizations and the unit prices to be used in estimating costs.

Eventually, the location was determined throughout; lines and profiles were run; embankment, drainage and paving quantities were ascertained from this preliminary information; preliminary designs for bridge and other structural quantities were determined; and unit costs were applied to produce a realistic estimate of all construction quantities and costs. An adequate contingency item was set up, and administrative, legal, and other similar costs were estimated.

Table I. Estimated Construction Costs

	Original Estimate as Amended Feb. 17, 1950	Estimate of June 28, 1951
Cost of construction:		
Under contract (or commitments completed)	$	$189,939,014
To be contracted (or committed)	149,030,000	5,168,986
Real estate	10,145,000	17,672,000
Repayment to New Jersey	11,150,000	9,700,000
Engineering	13,600,000	14,751,000
Administrative and legal	1,000,000	1,625,000*
Allowance for contingencies	18,760,000	.....
Net interest from construction fund, and financing costs	16,315,000	13,352,000
Total	$220,000,000	$252,208,000

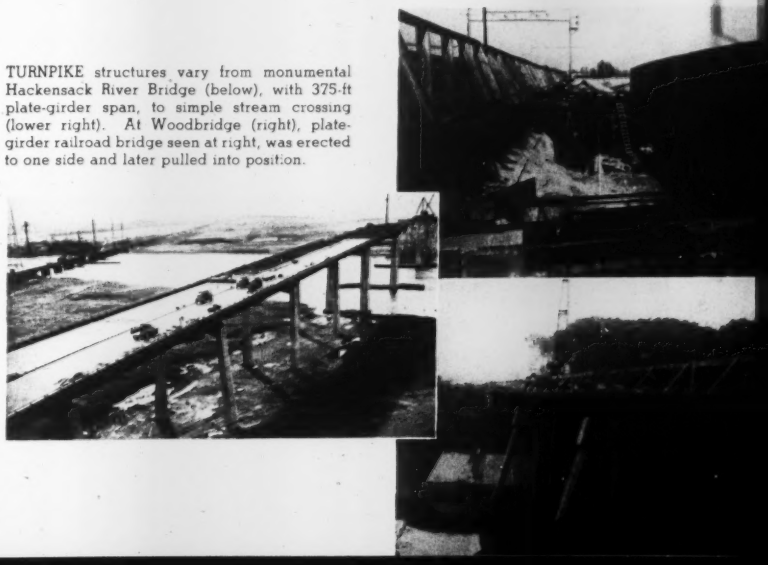
* Includes financing costs other than interest and commitment fees.

It was recognized that real estate costs would be very important and would greatly influence both the final location and the total project cost. A real estate department was set up by the Authority to study these matters with the engineers, and as soon as feasible, qualified local appraisers were put into the field to establish probable costs. Meanwhile attorneys were employed to investigate and solve the many legal problems constantly arising.

Late in August 1949 all the engineer principals were asked to meet with the traffic engineers and commissioners to put the then preliminary figures together to see where we were going and what the result would be, and to coordinate the preparation of reports. In a short time all reports were put in final form, and in September the cost and revenue reports, demonstrating the financial feasibility of the project, were issued.

Korean War Upsets Original Cost Estimates

One of the most enlightening, and sometimes chastening, experiences in any engineer's practice is that of learning how accurate and true his preliminary prophecies and estimates prove to be. We now know what happened to our 1949 reports on the



TURNPIKE structures vary from monumental Hackensack River Bridge (below), with 375-ft plate-girder span, to simple stream crossing (lower right). At Woodbridge (right), plate-girder railroad bridge seen at right, was erected to one side and later pulled into position.

New Jersey Turnpike. The following, taken from our letter report to the Turnpike Authority dated August 7, 1951, covers the increases in cost that had arisen:

"Due to a number of circumstances to be outlined in general here, there has been an increase in cost of construction for the New Jersey Turnpike over that originally contemplated, and this statement is intended to present our opinions on the changes which have taken place and their effects on cost. There has been of course no major change in the basic conception of the Turnpike as originally planned and financed, and the Turnpike as being built is substantially that covered by our original Consolidated Report.

"Our Consolidated Report of September 1949 showed a total project cost of $230,000,000. Later, a plan of financing was developed by the Authority which resulted in the sale of the required revenue bonds directly to a number of insurance companies, savings banks, and other investment agencies, without the necessity of a general public sale. These bonds were sold on a 'forward commitment' basis, and substantial savings in interest and financing costs, together with a modest adjustment in the allowance for contingencies, permitted the total estimated project cost and the issue of revenue bonds to be reduced to $220,000,000.

"A comparison between the tabulated project costs of February 1950 and July 1951 is as follows: [see Table I in box, page 33]

"In order to provide adequate funds for completion of the Turnpike with assurance, the Authority is requesting approval of the issuance of a total of $255,000,000 revenue bonds. This would be an over-all increase in cost for the project in the amount of $35,000,000. There are five major reasons which account for this substantial increase in over-all cost as follows:

"1. The Korean War and the general world situation.

"2. The enlarged requirements of the local communities, counties and state agencies which were affected by the Turnpike location and construction.

"3. The enlarged requirements of the railroads, power companies, and other utilities affected by the Turnpike location and construction.

"4. The wreck on the Pennsylvania Railroad at Woodbridge, N.J.

"5. Increased real estate costs.

"At the time the Korean War began in June 1950, bids had been received and contracts awarded for construction in the amount of $73,400,000, which compared with the original estimate of cost of $76,900,000 for those contracts. Up to that time more favorable than anticipated prices had been received on grading, drainage and foundation contracts, and there was every expectation that the total project cost as originally estimated would prove entirely adequate to care for all construction and other costs. Since the Korean War started, the low bids on all contracts awarded have totaled $96,600,000, in comparison with an original estimate of $64,200,000. The increased costs following the Korean trouble were reflected not only in the bid prices received from contractors but also in the engineers' estimates of cost submitted just before bidding, these estimates being quite comparable to the bids. A large part of the increase in construction cost has been related to steel structures, buildings and other facilities for servicing the Turnpike, and the construction of Turnpike paving. Competitive bids on alternate designs for pavement were received, and numerous adjustments in plans were made to secure a reduction in cost without lowering the standards of quality for the pavement, but the overrun in pavement costs alone proved to be in excess of $15,000,000 when awarded near the end of 1950. The increased costs, scarcity of materials, and the difficulties of construction which followed the outbreak of the Korean War were clearly beyond surmise at the time that this project was financed. The Authority policy of intensive design from the start and of awarding contracts early saved what might otherwise have been appreciable further increases.

"In a number of cases the present and future requirements of local communities as a result of construction of the Turnpike were more extensive than contemplated originally. As a result of the request of some of these communities and the State Highway Department, numerous structures carrying existing roads over or under the Turnpike had to be widened and lengthened, and in several cases wholly new structures not previously contemplated had to be built. In two cases, in Elizabeth and in Newark, court actions were necessary to support the position of the Authority and to avoid even greater demands and costs than were met. It is estimated that the increased cost of these facilities was over those originally contemplated by approximately $5,000,000.

"The State of New Jersey is so highly developed industrially and so built up that it was virtually impossible to know in advance all the requirements of the railroad companies, power companies, and other utility companies that were encountered. In several cases long-drawn-out discussions and conferences were necessary during development of final designs to determine the future needs of the utilities, particularly the railroad companies, since these had given no serious thought to their future needs until the building of the Turnpike was upon them. The basic state legislation requires that all utility changes must be borne by the Authority. In order to meet the present and future needs of these railroad and utility companies it became necessary to spend approximately $5,000,000 more than originally contemplated.

"The wreck of a Pennsylvania Railroad passenger train at Woodbridge, N.J., in the spring of 1951 took place at a point near the crossing of the railroad by the Turnpike. The public reaction to this wreck was of such character and the attitude of the railroad became such that substantial changes in Turnpike arrangements and construction procedure became advisable. The increased cost to the Turnpike as a result of this accident is something over $1,000,000, but the delays and complications resulting were even more burdensome.

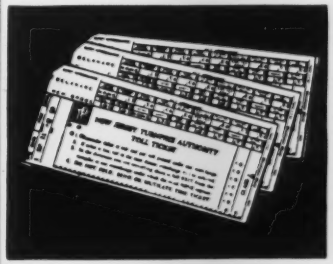
"The original estimate of cost for the acquisition of real estate for the Turnpike was $10,145,000. This estimate had been prepared by experienced appraisers who surveyed the entire route of the Turnpike and who established liberal cost estimates based on their experience and acquaintance with local conditions. The present estimate of real estate costs is approximately $7,500,000 above that figure. This increase reflects the difficulty of public acquisition of land from private owners in areas of high development. Generally this real estate was purchased in an advancing market, and the severance damages that developed were substantially in excess of expectations. The actual acquisition of real estate was in the hands of skilled and trustworthy negotiators, with all purchases reviewed carefully by the Authority members themselves. A large number of parcels, though small percentagewise, had to be acquired through condemnation proceedings due to in-

ability to reach agreement with the private owners otherwise. In spite of the strongest and most conscientious endeavor on the part of the Authority and its representatives, this substantial increase in land cost could not be avoided.

"It is our judgment that the need for increased funds for the completion of the New Jersey Turnpike came from circumstances beyond the control of the Authority members or its officers and representatives. These circumstances were both national and international in scope. We consider the new project cost of $255,000,000 to be adequate for the completion of this Turnpike, taking into account the fact that construction is in its final stages, very nearly according to schedule, and barring any unfavorable major developments in the international picture."

Many Civil Engineers Identified with Project

The New Jersey Turnpike is a magnificent public undertaking. Its construction will affect the movements of many, many millions of motorists in coming years. The effect of its building will be nationwide rather than statewide. A very large number of civil engineers may claim honor and gratification for having been identified with its construction. In its planning and building, we have performed a real service on behalf of our fellow men. Projects like the New Jersey Turnpike make us very proud to be called civil engineers, and we know that we will not lack respect and appreciation when we make possible such facilities for public use and benefit.



Turnpikes must be economically justified

Studies plus judgment establish economic feasibility

GEORGE W. BURPEE

Vice-President ASCE

Partner, Coverdale & Colpitts
Consulting Engineers
New York, N.Y.

NEW JERSEY TURNPIKE, which stretches 118 miles from the vicinity of the western approach to the George Washington Bridge to the Delaware Memorial Bridge south of Wilmington, is about to be put to use. It has been financed by the issue of $255,000,000 of 35-year bonds bearing about 3¼ percent interest. The estimated revenue is barely enough to pay the interest in 1952 but is likely to double in the first 5 years and to be sufficient to extinguish the debt completely within 25 years. That in a nutshell is the test of the economic feasibility of this project.

By economic feasibility is meant the ability of a project to pay for itself. A toll turnpike becomes economically feasible when an estimate of earnings indicates that it will pay maintenance and operating expenses (including insurance), interest on its debt, and enough over to extinguish the debt in 25 to 35 years. Estimates should indicate a margin of 20 to 50 percent over these requirements to serve as a cushion.

Sometimes the bond issue includes an initial reserve, in which case the cushion may be less. The reasons for a substantial margin for a construction project are: First, the risk involved in the estimate of construction cost and the possibility of increase in the total indebtedness without any offsetting increase in revenue; and second, the possibility that the revenue estimates may not be realized. Once a project is put into operation and its earning power demonstrated, the desired margin of earnings over bond service requirements becomes less. The rate of estimated growth of earnings has a very substantial effect on the feasibility of a toll turnpike or any other type of project launched by a revenue bond issue. If the indicated rate of growth is substantial, as in the case of the New Jersey Turnpike, a project becomes

feasible even though the margin of earnings over requirements for the first year or so is slight.

Why Finance by Revenue Bonds?

The primary reason for financing turnpikes by issuing revenue bonds is the lack of availability to states or municipalities of other sources of funds for the construction of express or limited access highways, adequate for present day needs. The credits of the states are fully used for normal highway and other public improvements. Resort has been had, therefore, to financing on such a basis that the user pays for the facility in accordance with his use.

Those who travel between New York and points south on Route 1 or 130, in combination with other routes, know that the capacity of certain sections of these highways is practically exhausted. The capacity of Route 1 between New York and New Brunswick can be increased only at very great expense, and southwest of New Brunswick at somewhat less expense. Route 130 south of New Brunswick is already in part a four-lane dual highway, and its capacity can be increased without too great expense, but under present conditions there are times when it is badly congested. The function of the New Jersey Turnpike is to permit vehicles that can use it for all or any part of a trip to enjoy the advantage of faster traveling time, less hazard and less congestion, thus relieving the existing highway system of much passenger car and truck traffic.

The vehicle for financing the New Jersey Turnpike, and in fact, most toll projects, is a bond issue secured solely by revenue. Such bonds are usually issued by an authority which is an agent for the state—in this case the New Jersey Turnpike Authority. All revenue, other than that required for operation and maintenance, accrues to the credit of the bondholders either for current interest and amortization or for deposit in a reserve to be used for such specified purposes as will be in the bondholders' interest.

Interest on revenue bonds is tax exempt and for that reason there is a wide market for them, even though today the issues run into large sums of money. Purchasers of the major part of the large issues—in the order of 50, 100, 200 or 300 million dollars—are the institutional buyers of which the life insurance companies are typical. The interest rates carried by bonds on construction projects today will range generally from $3\frac{1}{4}$ to $3\frac{3}{4}$ percent. Even though these bonds are secured solely by revenue, the reputation of the issuing body is a factor in the coupon rate, since the bond buyer considers that the issuing body, or the state of which the issuing body is a creature, has a moral obligation toward the bondholder.

Bonds on the New Jersey Turnpike carry interest at the rate of approximately $3\frac{1}{4}$ percent. The original issue was 220 million dollars and a supplementary issue, which was sold successfully in October 1951, was for 35 million. This is the largest issue ever put out for a toll highway. Rates of interest on going projects, such as the Triborough Bridge and Tunnel Authority and the San Francisco-Oakland Bay Bridge, run as low as 2 and $1\frac{3}{4}$ percent.

Steps in Determining Feasibility

Steps required in estimating economic feasibility are:

1. An estimate of vehicular traffic already in existence from which the Turnpike will secure its patronage. This is the potential traffic.
2. An evaluation of the advantages offered by the Turnpike as compared with existing highways.
3. An estimate of the optimum toll rates to be charged on each section of the Turnpike.
4. An estimate of the number of vehicles, by type and class, that can be diverted from the existing highway system because of the advantages offered by the Turnpike and at the toll rates adopted.
5. An estimate of the new traveling that the Turnpike will induce or create.
6. A projection of traffic and earnings into future years.

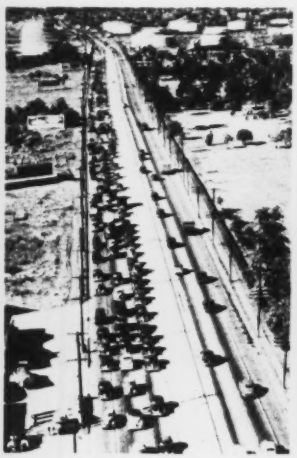
These steps were carried out in the studies for the New Jersey Turnpike, as will be described. They led to the conclusion that its construction was economically feasible.

1. Potential Traffic Surveyed

To find out how many vehicles now traveling routes which will be competitive with the Turnpike, might be diverted to it, origin and destination surveys were made at twelve different stations which covered the competitive routes from the George Washington Bridge on the north to the Pennsville-New Castle Ferry on the south. Each survey covered a continuous five-day period, including Saturday, Sunday and three weekdays. The counts were made during June and July 1949, none during the weeks that included holidays. Vehicles were stopped and the drivers questioned as to origin and destination of trip. For purposes of analysis the tributary area was divided into zones related to the termini of the Turnpike and to each of the 16 intermediate interchange points. The boundaries of each zone

OVERCROWDED highways necessitated construction of new north-south traffic artery across New Jersey. This extreme need was one factor in economic feasibility of Turnpike. New route will relieve overloading of existing highway net and save time and money for through traffic.

— Acme Wire Photo



were so chosen that, in so far as practicable, every vehicle entering or leaving the zone would pass through a common intersection at which a choice of routes would be available to it, either the Turnpike or the competitive highway.

At most of the survey stations it was possible, with the help of the state and local police and a sufficient number of interviewers, to question a large proportion of the drivers—enough to secure a representative sample of traffic flow. At all stations a continuous hourly count of all vehicles, classified by type, was maintained for the purpose of control and for comparison with records of the Highway Department's control stations. The number of vehicles interviewed at each station as compared with the number passing, for each five-day period, is shown in Table I.

In addition to these origin and destination counts, counts were made at two Raritan River Crossings, Edison Bridge and Victory Bridge, where the classification was by type of vehicle and by state and county of registration. At the Edison Bridge, 226,390 vehicles were counted in the five-day period; at the Victory Bridge, 83,542. The purpose of these counts was to obtain additional information as to the volume of traffic between the area north of the Raritan River and the New Jersey shore resorts.

In addition to securing the information described above as to origin and destination, automobiles were classified as to states of registration in four categories—New Jersey, New York, New England, and all other states. Trucks were classified as two-axle; three-axle single unit; and semitrailer.

From an analysis of these field counts a determination was reached of the number of vehicles that could logically use any part of the Turnpike. These constitute the potential traffic. The potential may be further analyzed by using the same data to determine the number to which the Turnpike offers such manifest advantages as to insure their patronage. The purpose of the origin and destination surveys is to determine the pattern of traffic flow and not to determine directly the volume of traffic available (although it is useful for that purpose also).

Results of the five-day counts had to be expanded to an annual basis. The expansion was effected for some stations by comparing the counts with those at the continuous daily recording stations maintained by the state. Such comparison made possible the determination of the ratio of the five days' traffic to the year's traffic at each location. By courtesy of the Delaware-New Jersey Ferry Co. it was possible to relate the counts on the Pennsville Ferry to the annual traffic, and by courtesy of the Port of New York Authority, to do the same for the counts at the Lincoln and Holland tunnels and those near George Washington Bridge. The total volume of traffic flow on the competitive highway routes was known from the State Highway records; that on the Delaware River ferries, from the ferry company records; and that on the Port Authority's Hudson River crossings, from the Authority's records. Therefore there was an excellent record of total volume of traffic for a long period of years in the past. The origin and destination survey furnished the data to break down these totals into the potential for the Turnpike or for any of its 17 sections. The final analysis developed the movements over each of the 17 sections from each zone to every other zone.

It is of the utmost importance in making an origin and destination survey that the survey stations and the periods of the count be such as to furnish a representative pattern of traffic flow, and that the factors used to expand the figures for the period of the count to an annual basis be appropriate and applicable so as not to overstate the annual volume.

TABLE I. PROPORTION OF PASSING VEHICLES, DRIVERS OF WHICH WERE INTERVIEWED

LOCATION	NUMBER INTERVIEWED	TOTAL VEHICLES	PERCENTAGE
Cranbury	54,571	55,692	...
Deans	55,748	57,530	...
Pennsville Ferry	38,299	54,837	69.8
Chester Ferry	23,117	29,483	78.4
Ridgefield	68,279	118,217	57.7
N.J. State 1 at Edgewater Rd	23,872	75,234	31.7
Lincoln Tunnel	53,188	58,970	90.2
N.J. State 3 east of eastbound entrance to Lincoln Tunnel	19,869	28,989	68.6
Holland Tunnel	148,584	180,133	82.3
Communipaw Ave (trucks only)	36,000	126,471	28.5
Newark Turnpike at Schuyler Ave	13,306	41,282	32.2
Newark Ave. to Pulaski Skyway	21,463	23,138	92.8
	556,326	849,976	65.5

2. Advantages of Turnpike Evaluated

The second step was to evaluate the advantages offered by the Turnpike so that an intelligent estimate could be made of the number of potential vehicles that can be diverted to it at the adopted toll rate. These advantages compared with those of the existing highway system are easier and safer driving, due to absence of congestion and elimination of delays at intersections. Specific advantages are savings in time or distance or both, or, particularly for trucks, reduction in expense. In the case of trucks, there is a substantial saving because the elimination of stop-and-go signals permits continuous travel from end to end of the route.

To compare travel times and distances, observations were made by riding over all the competitive routes from various parts of each zone, at different times of day, under varying conditions of congestion, in order to determine the average speed of travel on each section of the competing highway system as compared with the postulated time on the Turnpike. The estimated time saving over the full length of the Turnpike is 1 hour and 10 minutes for a passenger car and $1\frac{1}{2}$ hours for a truck. The saving in distance is 8 miles. The evaluation of these advantages is expressed by a toll schedule. The toll rates should be commensurate with the benefits offered. There is no way these benefits can be precisely measured for all the vehicles that will use any or all sections of the Turnpike.

The savings in time and distance are not the same over all sections. South of the Raritan River the general highway system offers much greater competition than it does north of it. The greatest congestion and the greatest possibility of time saving occur north of New Brunswick. This situation has been recognized in the tentative toll schedule adopted.

3. Toll Schedules Prepared

A pattern for toll schedules has been more or less set by the Pennsylvania, Maine and New Hampshire turnpikes. At least the results indicate what the user is willing to pay. The rates on the Pennsylvania Turnpike are about 1 cent a mile for passenger cars and varying rates for heavy trucks—3.75 to 6.25 cents per mile, depending on size. Considering the relatively low cost of the original section of the Pennsylvania Turnpike and the time when it went into operation, these rates are adequate. The Maine Turnpike, however, has a toll schedule for passenger cars of ap-

proximately 1½ cents a mile, and for heavy trucks of 2.26 to 3.38 cents. The New Hampshire Turnpike has a toll rate for passenger cars of 1 cent a mile. This low rate is due to the fact that the bonds are general obligations of the state and their service is not limited to toll receipts. Toll receipts to date, however, have proved more than sufficient to meet the debt service.

The initial toll rates proposed for the New Jersey Turnpike for passenger cars are slightly more than 1 cent a mile for the 83 miles at the south end, between the Delaware Memorial Bridge and New Brunswick, and slightly less than 3½ cents a mile on the northern 35 miles between New Brunswick and the George Washington Bridge. The rate for the full length of the Turnpike for passenger cars of $1.75 is equivalent to approximately 1½ cents per mile. The rate for a semitrailer traveling the full length is $1.50, equivalent to 3.8 cents a mile overall. This semitrailer rate varies from 2.8 cents a mile on the southern end to approximately 8½ cents on the northern end. The benefits in relief from congestion and time saving are substantially greater on the northern end, as any driver of a vehicle in this area well knows.

4. Diversions to Turnpike Determined

The fourth step is to determine the percentage of potential vehicles in each zone-to-zone movement that can be attracted to the Turnpike.

There is no way in which the Turnpike's advantages in convenience and ease of driving can be evaluated with any degree of precision and their effects expressed by means of a formula. Distance saving and time saving are more readily evaluated. Our experience indicates that time saving, unless the distance saved is very substantial, is the best general index to the ability of a toll facility to attract traffic to itself. Time saving is largely made possible by absence of congestion and easier driving, and therefore greater speed.

It is seldom possible after a toll facility has been built to test the estimates by more than over-all results. In two specific instances, however, where such tests were made, estimates of diversions based on time saving proved to be accurate within 1 or 2 percent, a degree of precision hardly to be expected. For these reasons, the estimates of diversions on the New Jersey Turnpike were based primarily on time saving, giving due recognition to the saving in distance and to greater ease of driving. No formula was used, but a general pattern was followed to insure consistency of treatment. In this process there is no substitute for experience and judgment.

In estimating diversions, a distinction was made between vehicles registered in New Jersey, those registered in New York, and those registered in other more distant states. The lowest rate of diversions was applied to New Jersey cars, the highest rate to those from more distant states, and the intermediate rate to New York cars. For potential vehicles that could use the entire length of the route, it was assumed that at a toll rate of $1.75, 75 percent of the cars from states other than New York and New Jersey would use the Turnpike; and that 70 percent of New York cars and 65 percent of New Jersey cars would do so. Drivers of New Jersey cars are assumed to be familiar with the New Jersey highway system, and therefore able to make better time over these highways than drivers from other states.

For a 35-mile section of the Turnpike between New York and New Brunswick, at a toll of $1.00, the diversions were taken at 70, 65 and 60 percent, respectively. The time saved is only 28 minutes, but this section is more congested by far than that south of New Brunswick.

On the most congested section of the highways, between Raymond Boulevard (Newark–Jersey City) and the northern terminus of the Turnpike, a distance of 10 miles, although the time saving was only 15 minutes, the percentages of diversions used were 63, 59 and 54 percent, respectively, with a toll of 40 cents.

On the 85-mile section between New Brunswick and Deepwater, with an indicated time saving of 36 minutes, the estimated percentages of diversions were 62, 58 and 53 percent, respectively, with a toll over this section of 90 cents. This reflects the ability of the competing highways in the southern area to accommodate traffic more readily than those north of New Brunswick.

A recent study of the Maine Turnpike showed that, for the period of observation, 90 percent of the foreign cars and 82 percent of the Maine cars that were potential to it for its full length made use of it at a toll rate of approximately 1⅓ cents a mile. However, only 60 percent of the potential trucks used it.

In considering the ability of the New Jersey Turnpike to divert traffic, the possibility of future improvements of competing highways becomes an important factor and due allowance must be made for such contingencies.

5. Induced Traffic Estimated

It is a common experience, and in fact one that goes back to the early days of transportation, that any new transportation facility creates a certain part of its own traffic. Experience with highways today follows the experience of railroads 75 to 100 years ago. The fifth step, therefore, is to estimate the volume of this induced traffic. There is no way in which such newly created traffic can be measured precisely although there are many analogies, more relating to bridges than to turnpikes, which throw some light on the subject. The Pennsylvania Turnpike came into operation at a time when it was not possible, because of wartime economy and gasoline restrictions, to differentiate between induced traffic and diverted traffic. The Maine Turnpike, based on recent counts, created additional traffic somewhere in the range of 20 to 40 percent of that obtained by diversion. Sufficient counts have not been made on the competing highways to furnish a conclusive figure.

Experience on the Philadelphia-Camden Bridge was that, following its construction, the total cross-river traffic on both the bridge and the ferries was 74 percent more than the ferries would have carried had no bridge been built. Similarly, the Holland Tunnel increased the total number of Hudson River crossings, including those by ferry, within a mile on each side of the tunnel, by 88 percent; and the George Washington Bridge did the same by 65 percent.

For the New Jersey Turnpike, the induced traffic was taken at 30 percent of the diverted traffic spread over a five-year period.

In estimating the volume of induced traffic, it is essential to give the greatest weight to the lower rather than the higher limits of the range, because this part of the traffic is so large in relation to the whole, and errors can have serious consequences to the financial stability of the project.

6. Future Growth Projected

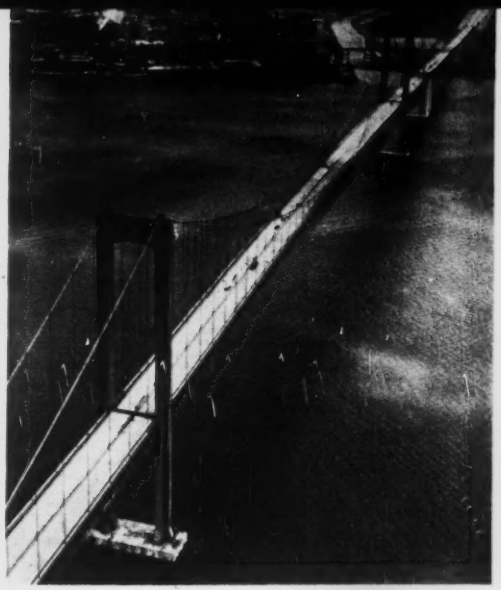
The sixth step was to estimate as well as might be the future rate of growth and to project the volume of traffic and revenue over a long term

in the future. The data which form the basis for such a projection include automobile registrations, gasoline consumption, past rates of growth on New Jersey highways and on the Pennsville–New Castle Ferry, the Chester Ferry, the Philadelphia–Camden Bridge, the Holland and Lincoln tunnels, and the George Washington Bridge. A study of the growth of traffic on these facilities indicates a very high rate of increase, with no present indication that the rate is diminishing, even though the Hudson River crossings between New Jersey and New York are now so congested as to discourage their use.

Over the period 1925 to 1950, inclusive, the annual increases in motor vehicle registrations have been as follows: in the United States, 3.6 percent; in New Jersey, 4.0 percent; and in New York, 3.3 percent. The annual rate of increase in motor-fuel consumption over the same period, which is the best single index of the use of motor vehicles, is as follows: in the United States, 5.8 percent; in New Jersey, 5.5 percent; and in New York, 4.5 percent. There is no present indication of a change in this average rate of growth.

Over a long period, 1931 to 1949 inclusive, the number of vehicles carried by the Pennsville–New Castle Ferry increased at the rate of 9.35 percent per year; over the shorter period, 1941 to 1949, inclusive, at 6.29 percent per year. The long-term rate of increase on the combined Philadelphia–Camden, Tacony–Palmyra and Burlington–Bristol bridges, from 1930 to 1949, was 3.5 percent; from 1941 through 1949, 4.6 percent per year. The increase on the Holland Tunnel, Lincoln Tunnel and George Washington Bridge from 1932 through 1949 was 6.24 percent per year; from 1941 to 1949, inclusive, 6.64 percent. The annual rates of increase following the elimination of gasoline rationing in August 1945 have been much greater than these long-term rates.

In considering the long-term future, consideration was given to the plans of various states for new highway construction, particularly completion of the Chesapeake Bay Bridge and the gradual improvement of highways connecting with it which will improve conditions of travel between Washington and the north; extension of the Pennsylvania Turnpike to the Delaware River; completion of the New York Interstate Parkway from Route 6 in Palisades Interstate Park in a northerly direction; completion of Route 4 Parkway in New Jersey, now under construction; construction of the New York Thruway; the continuous improvement of the Wilbur Cross Parkway in Connecticut; and proposed construction of the Massachusetts Expressway connecting the Wilbur Cross Parkway with New Hampshire and New England.



DELAWARE Memorial Bridge, opened in August 1951, furnishes adequate facilities at southern terminus of New Jersey Turnpike for motorists wishing to continue southward across Delaware River.

The recent completion of the Delaware Memorial Bridge at Deepwater will furnish an adequate connection at the southerly terminus of the Turnpike. Unfortunately, the facilities for crossing the Hudson at the northern terminus are even now congested and will not furnish an adequate connection between the Turnpike and routes to the east until additional crossing facilities are provided.

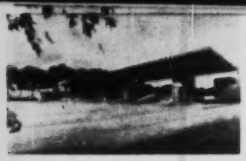
In view of all these facts, the annual rate of increase through 1956 was taken at 6.0 percent per year, and following 1956 the rate was taken as an arithmetical progression—that is, 7 percent in 1957, 8 percent in 1958, etc. The induced traffic was added to this increase at the rate of 6.0 percent in 1952; 9.0 percent for each of the years 1953 and 1954; 4.0 percent in 1955; and 2.0 percent in 1956, by which time it was believed that the effects of the new facility in creating new traffic would be fully realized.

Every step in the process of making traffic estimates requires the making of assumptions. Most of these assumptions are subject to check by comparison with the results of other facilities which, in one respect or another, are analogous. Considering the amount of money that is to be borrowed on the security of the estimated revenues, it is essential that the assumptions made be on the conservative side.

Gross revenues from tolls are, of course, the results of applying to each interchange-to-interchange movement the appropriate tolls and deducting from the grand total the estimated maintenance and operating expenses (including insurance). The result is the net operating revenue. To this must be added the non-operating revenue.

Non-operating revenue results primarily from sales of gasoline and automobile accessories at the various service stations, and rents from concessions for restaurants. The Turnpike Authority has provided its own facilities and has leased them to concessionaires for operation.

The sum of net operating and non-operating revenues is the amount available for paying the interest and amortization charges on the bonds. In connection with this study of economic feasibility, it is of great interest that the estimates of income from the New Jersey Turnpike indicate that it will barely earn its interest in 1952, but that it will grow rapidly thereafter and will extinguish its debt in a period of about 25 years. It is because of its location, and the obviously tremendous volume of potential traffic, that the Turnpike has proved to be economically feasible.



NEW JERSEY TURNPIKE

GENERAL DESIGN CRITERIA for the New Jersey Turnpike are here presented. The article also tells how the various construction contracts were scheduled so that the work would go forward in logical sequence to permit simultaneous completion of the various sections on a predetermined date. Some of

CHARLES M. NOBLE, M. ASCE

Chief Engineer, New Jersey Turnpike Authority, Trenton, N.J.

Standardized design and careful scheduling

DESIGNERS of modern express highways recognize the necessity of anticipating future developments in vehicle design and the desires and requirements of motorists, in view of the long life of highway materials and the extremely high capital cost of such routes. This is particularly true of toll highways when financed by long-term revenue bonds—the New Jersey Turnpike Authority bonds run for 35 years—since the financial success of the project is dependent upon enthusiastic public acceptance. The Turnpike must offer the motorist and the trucker facilities sufficiently superior to induce them to pay a fee for their use. Vehicular safety, sustained uniform speed, freedom from delays, ease and economy of vehicular operation, and relief from traffic congestion are paramount considerations.

Revenue-bond projects require that design and construction proceed as expeditiously as possible because interest must be paid during construction, and earnings must start at the earliest feasible date. The various elements must be put under contract in proper sequence to avoid paying unnecessary interest on any of them in advance of the date needed, and to assure that the entire project will be completed in all its component parts and ready for traffic on the scheduled date. Consequently an important function in planning the Turnpike was the careful selection of the scope of each contract and the scheduling for it of design, specifications, contract drawings, dates of advertising for bids and the construction period.

First it was necessary to conduct preliminary engineering studies leading to reports for the purpose of determining the financial, traffic and construction feasibility of the project. Determination of the general route and establishment of a cost estimate were important parts of this study. Also, to make the report realistic, it was necessary at the start to establish general geometric standards which would be feasible and fit the characteristics of the country to be traversed.

It was determined that the Turnpike should be a controlled-access express highway, which was defined as having all highway and railway grades separated, traffic in opposite directions divided by a safety mall, no left turns, specially designed traffic interchanges at reasonably long distances apart for entrance and exit of vehicles based on the right-turn principle, wide stabilized shoulders, moderate grades, and wide traffic lanes—all to be constructed on a wide right-of-way, with no access or frontage rights allowed to contiguous property.

These conclusions resulted in the following general geometric standards:

- Design speed, for the southerly 85 miles below the Raritan River, 75 mph; for the northerly portion, 60 and 70 mph
- Maximum grade, 3 percent
- Median width, 26 ft for southerly 85 miles, 20 ft for the remainder, including inner shoulders
- Shoulders, outside, 16 ft, of which 10 ft would be stabilized; inside, 5 ft stabilized
- Pavement lanes, 12 ft wide
- Horizontal curves, minimum radius, 3,000 ft
- Vertical clearance, 15 ft
- Non passing sight distance, to conform with design speed
- Right-of-way width, 300 ft south of the Raritan River and 250 ft north of it

Studies for the preliminary report confirmed the feasibility of these geometric standards. Accordingly they were adopted for the construction phase. They are more fully set forth in the next following article. Actually, no horizontal curvature of less than 10,000-ft radius was used, and no long grades exceed 2 percent in the 100 miles from the toll booths at the Delaware River to Elizabeth, N.J. South of the Raritan River, topography is favorable and generally in farm land except for the Camden area. Horizontal curvature ranged up to a radius of 180,000 ft in order to obtain sufficient length. Excessively long tangents were not sought, as it was felt they would make driving monotonous.

North of the Raritan River the route traverses a heavily developed residential-industrial region with many cross streets, railways and extensive railway yards. In spite of

the construction problems encountered are also discussed. The article is followed by four statements listing in detail: (1) geometric design standards for the Turnpike; (2) design specifications for Turnpike bridges; (3) design specifications for railway bridges; and (4) design standards for Turnpike storm-drainage structures.

BORDENTOWN-TRENTON interchange typifies up-to-the-minute safe highway design. Paramount consideration in designing Turnpike was given to vehicular safety, sustained uniform speed, freedom from delays, and ease and economy of vehicular operation.

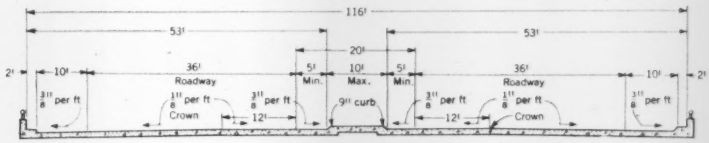
speed construction

these difficulties, long 3 percent grades were confined to the major river crossings over the Passaic and Hackensack, and it was necessary to use the minimum radius—3,000 ft—at two locations only. The remaining horizontal curves range from 3,600 up to 38,000 ft. A total of 68 horizontal curves occur on the entire 118 miles of the Turnpike. It was necessary to reduce the design speed to 60 mph at only two locations. The restriction at these locations was due to the vertical sight distance over major bridges, where physical problems were difficult and costs excessive. Curves were spiraled at locations where there were bridges which were on horizontal as well as vertical curves, and a series of compound curves closely following the locus of a true spiral were utilized for the transitions. Typical cross sections of the six-lane portion of the Turnpike are shown in Fig. 1. In the initial construction, now completed, the Turnpike is composed of 96 miles of four-lane road and 22 miles of six-lane road.

Because a large number of bridges were involved and because designs for them were to be prepared by eight engineering firms, a general design policy was established for these structures to assure reasonable uniformity and economy. One feature was the standardization of beam spacing so that roadway deck forms would be interchangeable for economy in construction. The general design policy for bridges is outlined in detail in the second and third articles following.

Similarly, the design policy for drainage structures is set forth in the fourth article following. In addition to the provisions for surface drainage, many thousands of feet of porous concrete pipe were laid to control ground water.

It was anticipated that, by mid-November 1951, interest charges on bonds issued for the construction of



SECTION FOR 6-LANE BRIDGES (EXCEPT HACKENSACK AND PASSAIC RIVER BRIDGES)

FIG. 1. STANDARD cross sections for six-lane northern portion of Turnpike provide two 36-ft roadways. On a 22-mile length between Route 35 interchange and Route 3 interchange, ultimate construction will provide 8-lane dual-dual roadways. Construction of 61½ miles of the four-lane portions contemplates future widening.

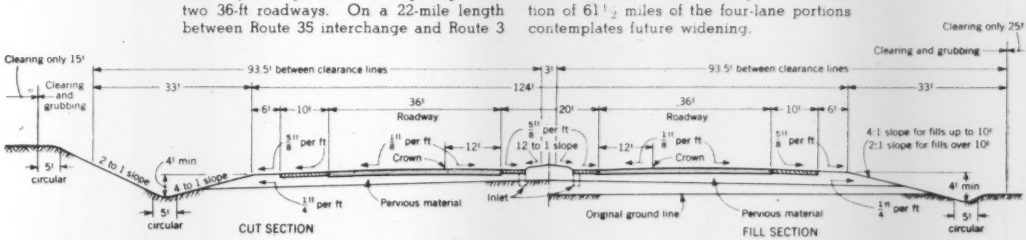


TABLE I. MAJOR CONTRACTORS, WITH TYPE AND AMOUNT OF WORK AWARDED

Contractor	Section	Type of Work	Contract Price
S. J. Groves & Sons Co.	1	Grading, drainage and 26 structures	$ 5,530,022
	1	3 structures and grading interchange at Deepwater	1,214,196
	1	Paving	6,276,080
	3	Grading and topsoil	402,780
	3	Paving	6,330,543
		Total	$19,753,930
Savin Construction Co.	2	Grading and drainage	$ 3,633,938
	2	15 structures	2,351,862
	2	Paving	5,409,111
		Total	$11,394,911
Geo. M. Brewster & Son, Inc.	3	Grading and drainage	$ 3,871,003
	4	14 structures	1,819,535
	4	6 structures	1,705,785
	4	Paving	5,886,788
	4	Paving	7,406,438
	4	1 structure	66,459
	7	Grading and drainage	1,900,283
	7	Grading and drainage	2,307,056
	7	Grading and drainage	5,680,143
	7	Paving	3,411,852
	6	Passaic River Bridge approach piers	1,142,805
	7	Bellman's and Paunpeck Creek bridges	838,973
	7	Bridge at Sta. 640	477,802
		Total	$39,514,922
Construction Aggregates Corp. Peter Kiewit & Sons' Co.	6, 7	Grading and drainage	$ 5,969,367
		Grading and drainage	6,916,698
		Total	$12,886,065
Bethlehem Steel Co.	6	Passaic River Bridge superstructure	$ 7,137,080
American Bridge Co.	7	Hackensack River Bridge superstructure	$ 5,454,289

TABLE II. PRINCIPAL TURNPIKE QUANTITIES

Earthwork	51,800,000 cu yd
Concrete in structures	530,000 cu yd
Steel and iron	191,200 tons
Curbing	211,000 lin ft
Sidewalk	42,000 sq yd
Drainage inlets and manholes	6,500 each
Bearing piles	1,884,000 lin ft
Drainage pipe	161 miles
Vertical sand drains	5,390,000 lin ft
Top soil and seeding	11,000,000 sq yd
Paving including cross roads	4,430,000 sq yd
Guard rail	391,000 lin ft
Improved shoulders	2,400,000 sq yd

TABLE III. CONTRACTS SUMMARIZED

Grading and drainage	$ 49,321,542
Major structures	25,587,711
Other structures	55,570,497
Paving	40,363,410
Buildings and concessions	8,998,000
Relocation and reconstruction of utilities	8,018,000
Toll booths and collection equipment	1,341,000
Miscellaneous	6,140,840
Total	$195,341,000

the Turnpike and toll earnings would total $48,000 per day. The fact that such large sums were involved was an incentive to rapid progress and dominated planning and scheduling.

Special Consultants to Turnpike Authority

Architectural Consultants

Bellhemmet & Wagner
Frank Grad & Sons

Special Consultants

Gordon Lorimer, Architectural Consultant to Consulting Engineer
Edward C. Mehm, Lighting
Dr. Paul Godley, Radio and Communications
A. H. Benedict, Pavement
Stewart Associates, Inc., Bituminous
Michael M. Burns, Landscaping
Dr. Gilbert M. Ahlgren, succeeded by Dr. Ralph E. Engel, Topsoiling and Seeding
Ralph Fisher, Highway Design
Marvin A. Riley, Jr., Contractor Prequalifications
James Driscoll, Liaison Representative with State Highway Department, Northern Sections
Norman Rigot, Liaison Representative with State Highway Department, Southern Sections

The preliminary reports indicating the feasibility of the project were completed on September 15, 1949. By September 22, eight firms of consulting engineers had been selected and directed to proceed immediately with field surveys, selection of detailed alignment, right-of-way maps, borings, final design, and complete contract construction plans. The first construction contract was scheduled for advertisement by mid-November 1949.

It was considered that the work could be accomplished in two working seasons, with grading and bridge foundations in the first, and paving and superstructures in the second. Such a program required that plans and construction proceed simultaneously throughout the entire length of the Turnpike.

First consideration was given to grading contracts, particularly in sections underlain by deep mud, and to substructures for major bridges. The rest of the program was scheduled in proper sequence allowing for the necessary construction period so that the work could be completed in time for succeeding operations, culminating in simultaneous completion in November 1951. Major contracts were arranged on the basis of not less than a million dollars each, the plans and specifications permitting larger contractors to bid the sum of several projects as a single bid. The principal contractors and the nature of the work awarded to them are given in Table I. A total of 80 major contracts have been awarded, of which 55 were for over a million dollars each. Table II gives the principal quantities involved in building the Turnpike, and Table III summarizes the contracts by type of work.

Scheduling of the major highway contracts is shown in Fig. 2, and Fig. 3 indicates the accumulated total dollar volume of construction contracts awarded.

Such a program required the utmost in contractor cooperation since several contractors often had to occupy the same area in order to push different phases of the work

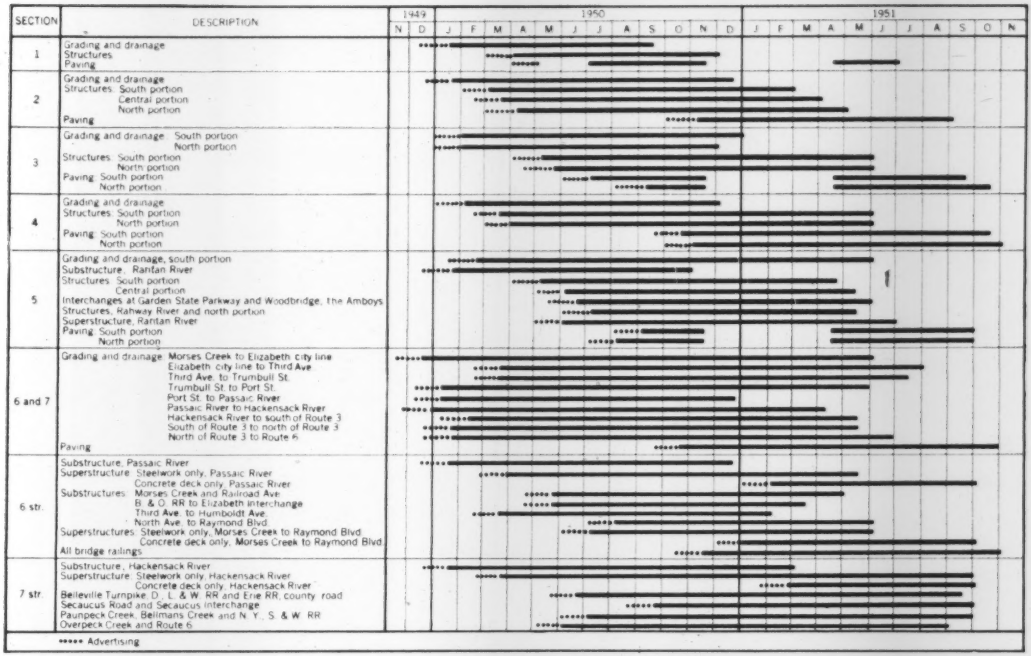

SECTION
DESCRIPTION
1949
1950
1951
N D J F M A M J J A S O N D J F M A M J J A S O N
1
Grading and drainage
Structures
Paving
2
Grading and drainage
Structures: South portion
Central portion
North portion
Paving
3
Grading and drainage: South portion
North portion
Structures: South portion
North portion
Paving: South portion
North portion
4
Grading and drainage
Structures: South portion
North portion
Paving: South portion
North portion
5
Grading and drainage, south portion
Substructure, Raritan River
Structures: South portion
Central portion
Interchanges at Garden State Parkway and Woodbridge, the Amboys
Structures, Rahway River and north portion
Superstructure, Raritan River
Paving: South portion
North portion
6 and 7
Grading and drainage: Morses Creek to Elizabeth city line
Elizabeth city line to Third Ave
Third Ave. to Trumbull St.
Trumbull St. to Port St.
Port St. to Passaic River
Passaic River to Hackensack River
Hackensack River to south of Route 3
South of Route 3 to north of Route 3
North of Route 3 to Route 6
Paving
6 str.
Substructure, Passaic River
Superstructure: Steelwork only, Passaic River
Concrete deck only, Passaic River
Substructures: Morses Creek and Railroad Ave.
B. & O. RR to Elizabeth Interchange
Third Ave. to Humboldt Ave.
North Ave. to Raymond Blvd.
Superstructures: Steelwork only, Morses Creek to Raymond Blvd.
Concrete deck only, Morses Creek to Raymond Blvd.
All bridge railings
7 str.
Substructure, Hackensack River
Superstructure: Steelwork only, Hackensack River
Concrete deck only, Hackensack River
Belleville Turnpike, D., L. & W. RR and Erie RR; county road
Secaucus Road and Secaucus Interchange
Paunpeck Creek, Bellmans Creek and N. Y., S. & W. RR
Overpeck Creek and Route 6
••••• Advertising

FIG. 2. GRADING AND DRAINAGE, construction of structures, and laying of asphalt paving were carefully scheduled to save interest on construction money and to complete work on time.

on a rapid schedule, employing many pieces of large, fast equipment. It is a tribute to the American contractor that the work went forward so effectively and in such a fine cooperative spirit.

The most serious and unexpected construction problem was the Korean War. It caught the Turnpike at the beginning of its first construction season, and aside from the resulting increase in cost, has presented the most formidable obstacle to rapid prosecution of the work. At times it appeared that these obstacles would be insurmountable. If the original schedules had not been set up on the basis of an early start, and allowance made for some leeway in construction time, the program would have been much more seriously affected.

To meet the war situation, the Authority set up an expediting staff, and each section engineer, in turn, established his own expediting staff, all to supplement the expediting efforts of the contractors. It has required the utmost effort of the material suppliers, the contractors, the section engineers, and the Authority to achieve the final result.

In addition to the war, a number of natural obstacles were encountered as for example, in the City of Elizabeth, where some 300 families had to be displaced from old low-rent housing and where it was impossible to find low-rent vacancies. This situation resulted in delay in obtaining access to the site and telescoped construction into a very short period.

The areas of deep mud found throughout the project, but particularly in northern New Jersey, on which heavy fills and structures had to be placed, constituted a threat to completion on schedule because of the time required for stabilization. The methods employed to assure rapid stabilization, described in the article by Messrs. Porter and Urquhart, were successful and contributed substantially to prompt completion of the Turnpike.

The Turnpike crosses 45 railway lines which required grade separation structures. Many of these railway facilities consist of extensive yards calling for viaducts up to 3,000 ft long, and a considerable number of the lines are electrified with 220,000-volt transmission wires and catenaries. Because of heavy, frequent, and fast railway traffic, contractors were required to conform with rigid rules and regulations which, in many instances, restricted the working time to a few hours in each 24. In one case, raising of steel above tracks and

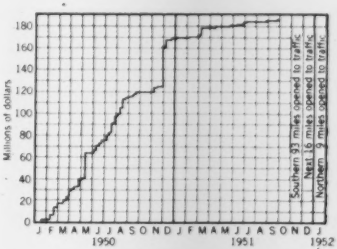


FIG. 3. CONTRACTS awarded for Turnpike construction in 21 months totaled nearly 190 million dollars.

electric feeders was restricted to a few hours on a weekend when the current could be shut off and all rail traffic suspended. These restrictions required careful planning, but did not seriously affect progress on the Turnpike.

At Woodbridge, where the Turnpike passes under the Woodbridge and Perth Amboy Railroad, construction was planned on the basis of utilizing bypass tracks so that the bridge could be constructed independently of rail traffic. Shortly after the bypass was put in service, the disastrous Woodbridge wreck occurred. Although the Public Utility Commission in its report on the wreck completely exonerated the Turnpike Authority of any blame, public opinion made it evident that it would not be advisable to put the bypass tracks into service again. It therefore became necessary to modify the entire method of operation, and to utilize a plan of underpinning the track under rail traffic, excavating beneath, building substructures, and rolling the pre-erected spans into place over a weekend when rail traffic could be suspended. Work went forward on an around-the-clock basis to such good effect that it did not delay the opening of the Turnpike.

So many organizations and persons have contributed to the successful Turnpike program that it is difficult to list them individually. The writer desires, however, to express gratitude and great appreciation for the outstanding contributions of Alfred E. Driscoll, Governor of New Jersey, the Commissioners of the Turnpike Authority, the staff, the general consultants, the section engineers, the contractors, material-men, labor, local and state officials, and the New Jersey State Highway Department. Those who participated in the project are keenly aware that its success was made possible by the outstanding caliber, sincerity and enthusiasm of the three Turnpike Commissioners.

Geometric design standards for Turnpike

THE FOLLOWING standards were the minimum. Higher standards were used whenever feasible but the design speed was adhered to. At junction areas, where there is a change in design speed, a gradual adjustment in design standards was made by using a straight line variation in the standards.

I. Design speed on main roadways was 75 mph between Deepwater and Bordentown, and 70 mph between Bordentown and the George Washington Bridge, except where the sight distance was restricted at the Passaic and Hackensack River bridges, where 60 miles per hour was used to realize an appreciable cost saving.

Design speeds on ramps are shown in the table under Item VIII.

II. Alignment on main roadways was given the flattest possible curvature: 10,000 ft radius or greater when feasible.

At 75 mph, the minimum radius is 5,000 ft; at 70 mph, 3,900 ft; and at 60 mph, 3,000 ft.

The minimum length of curve, including transitions, is 600 ft. Between reversed curves, in rural areas, the minimum distance is 1,000 ft; in urban areas, 800 ft.

Between curves in the same direction the minimum distance is 2,500 ft when the tangent and part of both curves can be seen by the driver. Curves in the same direction, with an intervening tangent less than 2,500 ft long, are connected with a flat curve unless no part of the far curve is visible to the driver while he is still on the near curve.

Approaches to exit ramps from the main roadway are "spiraled" to a minimum radius of 200 ft. Minimum distance between reversed curves on ramps was designed to include runout distance for superelevation of both curves.

III. Grades. Profile tangents were made at least 1,000 ft long.

Maximum grades on main roadways are 3 percent; on ramps upgrade, 7 percent; and on ramps downgrade, 5 percent.

The desired minimum grade was set at 0.5 percent. In flat country, where it was difficult to obtain 0.5 percent minimum grade, longitudinal drainage was provided by varying the depth of the "swale" ditches on the outside and by warping the cross slope of the inside shoulder. Velocity of water in side ditches was restricted to 2.5 fps or less. Ditch grades were held as low as 0.2 percent, depending on hydraulic conditions to keep velocity below 2.5 fps. Minimum cross slope of inner shoulder was $\frac{1}{4}$ in :12 in.; and maximum cross slope, $\frac{3}{4}$ in :12 in. Ample inlets and pipe drainage were utilized in median strips to assure freedom from flooding.

IV. Vertical curves. Minimum length of vertical curves on main roadways is 600 ft, except as follows:

When the algebraic difference in grades is $1\frac{1}{2}$ percent, the vertical curve is 500 ft long; and when the algebraic difference is 1 percent, the curve is 400 ft long.

Where gutter drainage is difficult, shoulders are warped as noted under Item III (minimum grades).

Where two opposite direction grades meet and the distance between vertical curves is 600 ft or less, or the entire length of vertical curve and 600 ft of both tangents cannot be seen by a driver, the minimum length of the curve, in stations, is equal to twice the algebraic difference in grades, in percent.

V. Superelevation of roadway. Table below gives standards.

Radius in Ft	Superelevation, %	Radius in Ft	Superelevation, %
3,000	3.0	4,500	1.8
3,200	3.0	5,000	1.5
3,400	2.8	5,500	1.3
3,500	2.8	6,000	1.2
3,600	2.6	6,500	1.0
3,800	2.4	7,000 to 10,000	1.0
4,000	2.2	Over 10,000	None

Ramps are designed for a maximum superelevation of 8 percent except for upgrade outbound ramps, which are 6 percent. Minimum superelevation on a 500-ft radius curve or sharper, is 5 percent. The rate of change of cross slope does not exceed 2 percent per second of time for the design speed. Changes in transverse grades are held below 2 percent per lane.

VI. Transition curves on main roadways are provided as follows:

Where the radius is between 3,000 and 3,200 ft, the minimum length of transition curve is 250 ft; between 3,200 and 3,500 ft, 200 ft; and over 3,500 ft, none.

On ramps, transition curves are omitted except for deceleration lane turnouts, and for high-speed direct-connection interchanges, where main roadway standards were applied.

VII. Sight distance on main roadways. In daylight, non-passing sight is based on an eye height of $4\frac{1}{2}$ ft above roadway, sighting an object 4 in. high. At 75 mph, 700 ft is provided; at 70 mph, 600 ft; and at 60 mph, 475 ft.

Profiles were also checked for sight distance with headlamps to provide a sight distance of 1,000 ft at 75 mph over summits,

and of 780 ft in sags. At a 60-mph design speed, 800 ft is provided over summits and 570 ft in sags.

VIII. Sight distance on ramps. Minimum sight distances are given in the table below, which is based on a perception time of 2 sec, brake reaction time of 1 sec, and a coefficient of friction of 0.2. Minimum sight distance = $4.4V + V^2/6$.

Radius in Ft	Design Speed on Ramp, mph	Min Sight Distance
100	20	155
150	25	215
200	30	280
300	35	360
400	40	440
500	45	535

These sight distances are based on a height of eye of $4\frac{1}{2}$ ft, viewing an object $4\frac{1}{2}$ ft high.

IX. Acceleration and deceleration lanes are 1,200 ft long.

X. Right-of-way width between Deepwater and Raritan River is 300 ft; and north of the Raritan River it is 250 ft, except through Elizabeth and in heavily built-up and industrial areas.

XI. Number of traffic lanes.

Between Deepwater and the North Camden interchange, initial construction provides four lanes, and ultimate contruction, four.

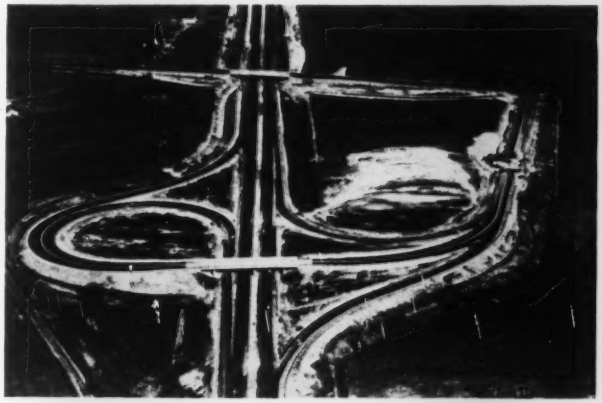
Between North Camden and the Route 35 interchange, four lanes are provided in initial construction; ultimate construction will have six lanes.

Between the Route 35 interchange and the Route 3 interchange, six lanes are provided in initial construction; to be eight lanes, dual-dual, in ultimate phase.

Between the Route 3 interchange and the Route 6 interchange, initial construction provides four lanes, and ultimate construction will have six lanes.

XII. Bridge clearance vertically, from the surface of the Turnpike pavement to the under side of bridges passing over the Turnpike, is 15 ft.

XIII. Cross roads. Geometric design standards for intersecting roads and for access or relocated roads were set as no less than those previously in existence on the road in question.



APPROACH to exit ramp at Burlington-Mount Holly interchange is spiraled. Minimum distance between reverse curves is designed to include runout distance for superelevation of both curves.

Design specifications for Turnpike bridges

1. Standard Specifications. Except as modified in this listing, and by other standards that were prescribed for Turnpike construction, the design of all highway bridges on the Turnpike was governed by the 1949 Standard Specifications for Highway Bridges of the American Association of State Highway Officials (Division III, pp. 121–210 inclusive). The modifications here listed apply to the articles of the AASHO Specifications as given in parentheses.

2. Dead Load (Art. 3.2.2). No provision was made in the design for a wearing surface on the concrete roadway slab of bridges. Instead, the roadway slab thickness required by the design was increased $\frac{1}{2}$ in. to allow for wear.

3. Live Load (Art. 3.2.3). The live load for all bridges carrying Turnpike traffic was taken as H20-S16. The live load for other bridges was mutually agreed upon with the public body involved. The following live loads were suggested as generally appropriate: For state highway routes, H20-S16; for other primary roads, H20; and for secondary roads, H15. The classification of primary and secondary roads was according to the Design Standards of the AASHO.

4. Curb Loading (Art. 3.2.11, Lateral Loads). Curbs at sidewalks and at median strips, for bridges carrying Turnpike traffic, state highway roads or other primary roads, were designed to resist a lateral force, applied at top of curb, of 1,000 lb per lin ft.

5. Sidewalk, Curb and Median Strip Loading (Art. 3.2.11, Vertical Loads). All curbs, sidewalks, and median strips, and their immediate supports, where curbs are 10 in. or less above the roadway surface, for bridges carrying Turnpike traffic, state highway roads or other primary roads, were designed for a wheel load of 12,000 lb, with normal impact, at 150 percent of normal allowable unit stresses.

6. Railing Loadings (Art. 3.2.18). All railings adjacent to the roadway and sidewalks for bridges carrying Turnpike traffic, state highway roads or other primary roads, were made up of a solid parapet, or its equivalent, not less than 18 in. high, surmounted by a metal rail. The top member of the metal rail was designed to resist a lateral horizontal force of 150 lb per lin ft together with a simultaneous vertical force of 100 lb per lin ft. The parapet was designed to resist a horizontal force of 600 lb per lin ft, applied at the top of the parapet. This parapet load was not considered to act simultaneously with the load specified for the metal rail. The parapet load was considered to act simultaneously with the load specified in Paragraph 5 above, and the unit stresses for such combined loads were not allowed to exceed 150 percent of the normal allowable unit stresses. For very short bridges and bridges whose decks were to be covered with fill, consideration was given to carrying the typical roadway guard rail across them.

7. Earth Pressure (Art. 3.2.18). Abutments and retaining walls along highways

were proportioned to withstand horizontal pressures not less than that given by a fluid weighing 35 lb per cu ft, the weight of the compacted fill back of the walls being taken as 120 lb per cu ft.

8. Camber of Beams and Girders (Art. 3.6.85). Camber of beams and girders, where provided, was made equal to the deflection for full dead load. Whether camber was or was not provided, the construction was required to be such that after full dead load deflection, the finished roadway surfaces would conform to those required.

9. Wind Loads (Art. 3.2.14). Wind loads on the structure were assumed to act either transversely, longitudinally or diagonally. The exposed area for transverse wind load on the structure was as specified in (1), except that in stringer spans, the number of stringers was taken as a maximum of 4. The exposed area for longitudinal wind load on the structure was taken to be one-half the areas of all truss members, outstanding legs of stiffeners on girders, sway bracing, floorbeams, cantilever brackets, stringer diaphragms, railing posts, and other members as seen in cross section. Diagonal or quartering winds, at an angle of 45 deg with the bridge center line, were assumed to give simultaneous loads equal to 0.7 of the transverse wind load and 0.7 of the longitudinal wind load.

In the design of the substructure, including all elements which support the superstructure girders or trusses and their attachment to the substructure, provision was made: (*a*) for one-half of the transverse loads specified in (1) and (2) acting with the live load; and (*b*) for a wind pressure of 50 lb per sq ft acting transversely, longitudinally or diagonally on the unloaded structure.

In the design of lateral bracing, the assumed wind loads were assumed to be those specified in (3) or the sum of those specified in (1) and (2), at normal allowable unit stresses, or those specified in (5) at 125 percent of normal allowable unit stresses, whichever would give the greater sectional area. In the design of members for combined effect of live load and wind load, the assumed wind loads were assumed to be one-half of the sum of those specified in (1) and (2).

10. Bracing between Compression Members (Art. 3.2.11). The lateral bracing of the compression chords or flanges of trusses and deck girders, and between the posts of viaduct towers, was proportioned for a transverse shear in any panel equal to 2½ percent of the total axial stress in both members in that panel, in addition to the shear from the specified wind loads. To provide for these combined shears, the bracing stresses were taken as 125 percent of the normal allowable unit stresses.

11. Depth Ratios in Superstructure (Art. 3.6.11). In determining the ratio of the depth to the length of span for composite beams, the thickness of the concrete slab plus the depth of the steel beam was considered as the total depth.

12. Welding (Art. 3.6.55). Welding of cover plates to rolled beams used as stringers, floorbeams, or girders, was required to be by continuous welds.

13. Curbs (Art. 3.1.9). Generally, for all bridges carrying Turnpike traffic, side curbs were 9 in. high with a slope back of 1½ in. in this height; and center island curbs were provided with a slope of 45 deg. The Design Standard furnished by the Turnpike Authority provided for exceptions to the criteria indicated here for curbs.

14. Grade of Reinforcement (Art. 3.4.12). The designs were made on the basis of Intermediate Grade Reinforcement.

15. Reinforcement in Concrete Roadway Slabs (Art. 3.3.2). The longitudinal reinforcement in the tops of concrete roadway slabs where the main reinforcement was perpendicular to traffic was not less than 0.20 sq in. per ft of width. The use of bent-up rods in concrete roadway slabs generally was dispensed with. At points of negative moment, tied straight bars generally were used.

The general consultants prepared formulas pertaining to the relationship between positive moments in slabs and long shallow spans, by which each consulting engineer was to test long shallow spans and make provision for additional moment where necessary.

16. Reinforcement for Temperature in Abutments and Retaining Walls (Arts. 3.5.3 and 3.5.4). The horizontal reinforcement specified near exposed surfaces was to be not less than 0.44 sq in. per ft of height.

17. Pouring Sequence for Slabs on Continuous Beams or Girders (Art. 3.3.2). Slabs on continuous beam spans or continuous girder spans were poured according to a sequence which would reduce to a minimum the dead load tensile stresses in the slab due to any composite action of slab and beam or girder which might develop, and which would avoid such tensile stresses in a partially set slab. The required sequence was shown on the plans, which also showed the sections in which the slab was to be poured, the direction of pouring in each section, the order of pouring the sections, and the minimum interval of time allowed between the pouring of successive sections.

18. Haunches for Slabs Supported on Steel Beams (Art. 3.3.2). When concrete slabs were to be supported on steel stringers, girders, or other beams, the bottom of the concrete slab was placed above the top of the steel support to provide a concrete haunch. The haunch was made deep enough to insure that the concrete slab could be constructed to the depth shown on the plans with its top at the required surface after full dead-load deflection, and without decrease in slab depth at the steel support after suitable allowance for beam camber, tolerances and for variation in camber of the steelwork from that specified.

Slab panels between haunches were of uniform width to effect economies in the construction of forms. Beam haunching was made of variable width corresponding to the required beam spacing so that a uniform panel width could be used between haunching.

19. Composite Beams (Art. 3.9.3). Composite beams were designed on the assumption that no temporary supports would be provided for the beams during the placing of the permanent dead load. In composite beams used for continuous structures, the design for negative moment was made on the assumption that only the structural steel beam and the reinforcing steel in the slab are effective. Consideration of composite action in the design of bridge decks was at the discretion of the consulting engineer on the section.

20. Shear in Composite Beams. In composite beams used for continuous structures, the horizontal shear at the junction of the slab and the structural steel beam in regions of negative moment was computed on the assumption that the slab was to be fully effective even though assumed ineffective in the design for negative moment. Shear devices were designed for the shears so computed.

Generally, the use of continuous composite beams was avoided, but the final decision as to their use in order to meet any special condition was made by each consulting engineer for the section involved.

21. Shear Devices for Composite Action (Art. 3.9.6).

(1) Plans showed shear devices of the channel or bulb angle types, and the load in pounds or in pounds per linear inch for which each such shear device was designed.

(2) A statement was included in the Supplementary Specifications as follows: "Where the plans provide for composite beam action by means of shear devices welded to the tops of the beams, shear devices of other types may be substituted by the contractor provided they meet the approval of the engineer as to type and strength, and that there is no increase in cost to the Authority. Payment will in all cases be made for the weights of the shear devices shown on the plans."

(3) The particular section of channel or bulb angle used for a shear device was such as to permit the use of welds of adequate size. To obtain good welds, the sizes of fillet welds were required to be not less than the following:

Size of Fillet Weld In.	Max Thickness, in In of Flange Element to Which Weld Is Applied
5/16	1/2
1/4	3/4
5/16	1 1/4
3/8	2

(4) Welds were designed for horizontal shear parallel to center line of beam at an allowable unit stress of 10,000 psi on the minimum section of the weld, giving allowable shear on fillet welds for channel and angle shear devices, as follows:

Size of Fillet Weld, In.	Allowable Shear per Lin In. of Weld, in Lb.
5/16	1,326
1/4	1,768
5/16	2,210
3/8	2,652

(5) Welds for attachment of the channel or bulb angles were distributed equally between the back and the toe of the section. Intermittent welds were permitted.

(6) For heavy beam flanges, a 4-in.

car-building bulb angle weighing 11.8 lb per lin ft generally was used. This angle has a height of 4 in., a bottom flange width of $3^1/_2$ in., a top flange width of $1^1/_2$ in., and a thickness of $^3/_8$ in.

(7) The concrete cover over the ends of the shear devices was not permitted to be less than 2 in.

(8) Each shear device was placed on the beam so that the pressure of the concrete for maximum load on the device was against the back of the channel or bulb angle.

(9) The allowable pressure between the concrete and the channel or bulb angle was 3,000 psi on the effective area. The effective area was taken as an area having a length equal to the length of the channel or angle and a height equal to the sum of the thickness of the bottom flange at the front face of the web and 1.5 times the thickness of the web. For the 4-in. 11.8-lb bulb angle this gives an allowable load per lin in. of angle equal to 2,810 lb, as follows:

$$3{,}000\,(^3/_8 + 1.5 \times {}^3/_8) = 2{,}810$$

(10) When the direction of the load on a shear device was reversed during the passage of the live load over the structure, the maximum load in each direction was determined, and the design load taken to be the sum of the larger load and one-half of the smaller load.

(11) The engineer was authorized to accept as equivalent shear devices, Alpha spirals designed in accordance with the requirements of the 1949 Alpha Composite Construction Engineering Handbook of Porete Manufacturing Company, except as follows:

(*a*) Allowable unit stress on the cross section of a spiral rod was to be 16,000 psi.

(*b*) Allowable unit stress on welds on the critical section was to be 10,000 psi.

(*c*) Provide for reversal under passage of live load, as specified above for channels and bulb angles.

(*d*) These requirements resulted in the following allowable loads per connection of spiral rod to beam and the following welds:

Dia. of Spiral Rod, In.	Load per Connection, Lb	Welds per Connection
$^1/_2$	6,280	Two $^1/_4$", $1^1/_2$" long
$^5/_8$	9,810	Two $^5/_{16}$", $1^1/_2$" long
$^3/_4$	14,130	Two $^5/_{16}$", $2^1/_2$" long

22. Deck Beams and Girders. Fascia beams and girders were designed to have a uniform depth for the full length of bridges. Interior beams and girders were varied in depth according to the span, but could not be deeper than the fascia beams and girders. Field splices in deck beams and girders were located in accordance with the experience and judgment of the consulting engineer. Riveted field splices were used for webs and flanges.

23. Maximum Pitch of Rivets (Art. 3.6.22). For sealing, the pitch in a single line adjacent to a free edge of an outside plate or shape was not permitted to exceed 4 in. plus four times the plate thickness, nor to exceed 7 in. If a second line of rivets was used, uniformly staggered with those in

SIMPLICITY and economy were basic factors in design of all Turnpike bridge structures. Typical of this design principle are the structures here shown under construction: Trumbull Street Viaduct (top); Hightstown-Trenton Interchange at Route S-33 (center); and Rahway River Bridge (below).

the line adjacent to the free edge, at a gage, g, less than $1\frac{1}{2} + 3t$ in. therefrom, the staggered pitch of the rivets in the two lines was not permitted to exceed

$$3\text{ in.} + 4t - \tfrac{3}{4}g, \text{ nor } 7 - \tfrac{3}{4}g$$

but need not be less than the requirement for a single line, where

t = thickness, in inches, of the thinnest outside plate or shape.

24. Stitch Rivets (Art. 3.6.23). In compression members, if the rivets on adjacent lines were staggered and the gage, g, between the line under consideration and the farther adjacent line was less than $24t$, the staggered pitch in such two lines was not permitted to exceed

$$12t, \text{ nor } 15t - \tfrac{5}{4}g.$$

25. Expansion and Contraction (Art. 3.6.16). The normal shop temperature of structural steel was assumed as 68 deg F, and provision was made for a temperature range from a minimum of −20 deg F to a maximum of 120 deg F.

26. Bridge-Deck Joint Treatment. No wide space or gap was permitted between the ends of beams at the piers for structures passing over the Turnpike, nor were drainage gutters or pipes located at the joints over the piers. Expansion and contraction movements on such structures were concentrated at the abutment and cared for by open joints. These joints were provided with suitable drainage details, arranged to be hidden from view as much as practicable.

a **Open Joint Without Fingers.** The maximum opening at minimum temperature was not permitted to exceed 1 in., and all such joints were armored.

b **Joints at Ends of Small Single-Span Bridges.** These joints on spans up to 50 to 70 ft long, according to the judgment of each consulting engineer, were closed with a copper strip as a water stop and with premolded joint material above the copper strip. This type of joint was not armored.

c **Deflection Joints for Beam Spans.** At a pier where there are two fixed shoes, or where there is one fixed shoe and one expansion shoe, or two expansion shoes, the tops of the flanking beams were tied together with longitudinal strap plates. These joints are closed as noted for joint (*b*) above, and are unarmored.

d **Deflection Joints for Girder Spans.** With either one fixed shoe and one expansion shoe at the pier, or with two expansion shoes, the girders of the flanking spans were tied together with longitudinal straps at the top flange. Such joints were closed as for joint (*b*) above.

27. Bridges Crossing Over Turnpike. Where a small hidden abutment is used, the slope in front of the abutment was designed to be 2:1. The top of the slope along the face of the abutment was made level transversely, and the toe of the slope in no case extended beyond the back face of the adjacent pier. The length of the end spans was therefore determined by this requirement. It was necessary to determine the controlling point at the back face of the pier and proceed from there in determining the span length. This point, in general, was at the lowest elevation of the underpass although it was affected by the skew and superelevation in the overhead structure. Pipe culverts were carried under the fill to connect the adjacent Turnpike ditches. The above applied in general where a secondary road was carried over the Turnpike and fills were used for approaches. Other situations were handled in a consistent manner.

28. Open Expansion Joints at Abutments at Tops of Embankments. A gutter in the bridge seat will collect water coming down the joint. Deflector plates, if necessary, were installed near the tops of the beams to throw the water away from the beams. Backwalls of abutment and gutters were treated to avoid deterioration of the concrete. The exact method of taking the water out of the gutter and carrying it to a suitable drainage channel was determined by the consulting engineer, except that no metal gutters were permitted.

29. Open Expansion Joints at Piers and High Abutments, if on a longitudinal grade, were provided with roadway drains above them so as to prevent water from reaching the expansion joint. A gutter in the bridge seat was provided for the collection of any water that might pass through the open joint. The exact method of taking the water from this gutter to a suitable drainage channel was determined by the consulting engineer.

30. Bridge Shoes. In so far as practicable, the height of both the fixed and rocker shoes on the piers was made constant for each structure. Bridge shoes at abutments were concealed in accordance with the approved drawings, as submitted by the consulting architects.

31. Painting of Steelwork. All exposed steelwork is painted in accordance with the pertinent specifications.

32. Approach Slabs and Curbs. Reinforced concrete approach slabs were used adjacent to all abutments regardless of the type of approach paving. Approach slabs were made 10 in. thick at the outer end and 16 in. thick at the abutment. Reinforcement generally was provided in the top and bottom of the slab, both ways, and of such sizes and spacing as were determined by the engineer in accordance with the requirements of the individual structures.

Reinforced concrete approach slabs were a part of paving contracts. Bridge contracts, therefore, provided for an appropriate bridge seat for the slab. While slabs were required to be 16 in. thick, the individual consultants determined the actual size and depth of the bridge seat to be provided. Where necessary to prevent raising during mud jacking operations, the approach slab was anchored down to the abutment.

Where concrete curbs were used on approaches adjacent to abutments, they were reinforced as beams and detailed to permit mud jacking of the adjacent approach slabs.

BRIDGES crossing over Turnpike, with small hidden abutments, have 2:1 slopes in front of abutment. Toe of slope in no case extends beyond back face of adjacent pier. This requirement governed length of end spans.

Design specifications for railway bridges

1. **Superstructure.** Except as otherwise agreed on with the railroads, and except as modified below, the 1949 Specifications for Steel Railway Bridges of the American Railway Engineering Association governed the design of the superstructures of all bridges carrying railway traffic over the Turnpike. The live load used for design was agreed on with the railroad.

2. **Substructure.** Except as otherwise agreed on with the railroads, and except as modified below, the 1949 Standard Specifications for Highway Bridges of the American Association of State Highway Officials governed the design of the substructures of all bridges carrying railway traffic over the Turnpike.

Surcharge loading for walls adjacent to railroad tracks was determined as follows:

In calculating the surcharge due to a track, the entire load was taken as distributed uniformly over a width of 14 ft for a single track or tracks spaced more than 14 ft on centers, and the distance center to center of tracks where tracks were spaced less than 14 ft.

In calculating the pressure on a retaining wall, where the filling carries permanent tracks or structures, the full effect of the loaded surcharge was considered where the edge of the distributed load or the structure was vertically above the back edge of the heel of the wall. The effect of the loaded surcharge was neglected where the edge of the distributed load or the structure was at a distance from the vertical line through the back edge of the heel of the wall equal to h, the height of the wall. For intermediate positions, the equivalent uniform surcharge load was taken as proportional. For example, for a track with the edge of the distributed load at a distance of $h/2$ from the vertical line through the back edge of the heel of the wall, the equivalent uniform surcharge load is $\frac{1}{2}$ the normal distributed load, distributed over the filling.

Design standards for Turnpike storm-drainage structures

TO OBTAIN consistency in the design of drainage facilities throughout the Turnpike, the following policy was generally followed:

1. **The rational method** was utilized in determining pipe sizes based on gravity flow. Most culverts 36 in. and larger in size are under the jurisdiction of the State Division of Water Policy and Supply. The New Jersey State Water Policy Commission favors the rational method for culvert sizes up to 5 ft × 5 ft, unless flood records are available on which to base design.

2. **Between Route 35** and Morse's Creek, initial pipe sizes were designed to accommodate an ultimate 8-lane dual-dual highway.

3. **A self-cleaning system** was designed utilizing inlets. Catch basins were not used. To assure self-cleaning, pipes were designed on a grade that would provide a minimum velocity of 3 fps when flowing one-third full.

4. **Minimum diameter of pipes** is 18 in., except that, for runs less than 100 ft, a 15-in. diameter was used, and for runs less than 40 ft, where some 12-in.-diameter pipe was used.

5. **Pipes and culverts** were designed for the following rainfall frequencies: For systems carrying Turnpike roadway drainage, 10 years; and for cross pipes or culverts carrying drainage from one side of the Turnpike to the other, 15 years. The roadway is designed above all known high water. Freeboard above inside top of pipe or culvert is at least 4 ft. Where future building and street development was indicated, the runoff was based on full development and the freeboard adjusted upward accordingly.

Outfalls from underpasses in cuts, from which water cannot escape, were designed for a rainfall of 25-year frequency, but based on utilizing head up to the surface of the lowest roadway inlet grating.

6. **The spacing of inlets** for draining the Turnpike median strip conformed to the accompanying Table I, as indicated in the last column, headed "Used."

7. **Inlet gratings** have a capacity to admit runoff from 10-year storms, except as noted in Section 5. It was recognized that a narrow inlet grating cannot always suck in a broad sheet of water flowing in the gutters on continuing grades. Some water will flow over such a grating and overtax the gutter below. To avoid this condition, double in-

TABLE I. TURNPIKE INLET SPACING FOR MEDIAN STRIP

I = 5.3 in. per hr for 5 min; Manning's n = 0.02; c (runoff) = 0.9

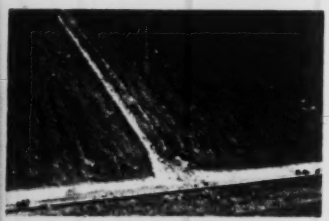
Roadway Grade, Percent	Gutter Width, Ft	Gutter Grade, Percent	Transverse Gutter Slope, Percent	High Point of Gutter Reverse Grade Same as Gutter Grade	Inlet Spacing, in Ft		
					By hydraulic requirements	By geometric requirements	Used
0.00	6.0	0.40	2 to 6	Midway between inlets	570	120	120
0.20	6.0	0.40	2 to 6	40 ft downgrade from inlet	570	160	160
0.40	6.0	0.40	5	None	420		250
0.50	6.0	0.50	5	None	472		300
0.75	5.0	0.75	5	None	350		325
1.20	5.0	1.20	5	None	450		350
Steeper	5.0	...	5	None	...		350

lets, spaced 15 to 20 ft apart, were utilized where necessary.

8. **In the design of pipe cross-drainage** and Turnpike roadway pipe drainage discharging into Turnpike side ditches, headwalls were omitted on pipes less than 24 in. in diameter wherever conditions were favorable. Aprons were built on the downstream end to control erosion and maintenance where required. Cutoff walls were constructed at the outfall end of aprons where high velocities were expected. Exposed ends of pipes were painted green wherever visible from the Turnpike roadway, and mounded over with earth to facilitate machine mowing.

9. **Drainage pipes** discharging on the side of Turnpike fills above the toe of the slope are provided with corrugated asphalt coated pipes installed below the surface of the fill slope, to convey water to the bottom of the slope. When the volume of water is small, half-round corrugated metal drains, 12 in. or more in diameter, were set flush with the surface of the fill slope. These pipes were extended beyond the toe of the slope unless protective devices were constructed to control erosion and maintenance.

SOD was placed (right) on slope of medial strip of Turnpike north of Route 40 in September 1951. Drainage inlet in foreground will be covered by grating.



EMBANKMENT DRAINAGE (above) is carried down slopes in half-round corrugated metal drains 12 in. or more in diameter.

INLET GRATINGS for Turnpike side drains have capacity to admit runoff from 10-year storms. Where necessary, double inlets 15 to 20 ft apart were used to prevent flooding of downgrade gutters.

CULVERTS carrying drainage from one side of Turnpike to the other are designed for 15-year rainfall frequency, and systems carrying roadway drainage, for 10-year frequency.

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Sand drains expedited stabilization of marsh section

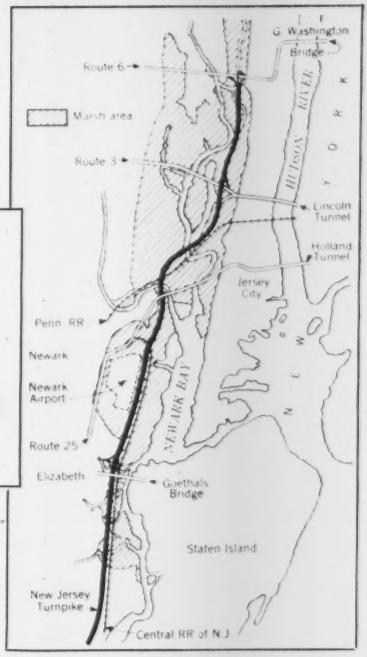


FIG. 1. IN SECTION of Turnpike that crosses New Jersey Meadows, original foundation consisted of wet silt and mud to depths up to 250 ft. In this section 20,000,000 cu yd were stabilized.

A LONG SECTION at the northern end of the Turnpike was routed over the New Jersey Meadows (Fig. 1). This route was chosen to avoid heavily built-up industrial and residential areas in Newark, public institutions in Hudson County, a second crossing of the Hackensack River, and other residential areas. The Meadows are a geological formation consisting of deposits of mud and silt with a high water content, varying in depth from a few feet to 250 ft.

Several methods have been used for the construction of roads and other structures on mud of this type:

1. Where the mud is shallow (5 or 6 ft deep) an excavation and backfill method usually has proved adequate. This method has been used for depths of mud up to 20 ft or more but at relatively high costs.

2. A more economical method, utilized extensively across shallow mud on the Turnpike, is to cover the meadow with free-draining sand 3 or 4 ft in depth and then to superimpose an overload fill on this sand fill to obtain rapid consolidation and stabilization during construction.

3. A third method is the sand-drain method, which may prove economical for any depths exceeding 10 ft.

Where the cost of fill is low and disposal areas for the mud are readily available without excessive haul, the first method listed—excavation and backfill—often can be used economically. On the northern section of the Turnpike this method did not prove generally desirable even where the mud was shallow because fill costs were high and disposal areas were difficult to obtain. On a section between the Rahway River and Morse's Creek, a distance of 1.10 miles, where the depth of mud varied from 15 to 25 ft, alternate bids were taken on this method and the sand-drain method. The latter showed a saving of nearly one million dollars.

During the preliminary and design studies for the northern part of the Turnpike, approximately 800 test holes ranging up to 212 ft in depth and aggregating 29,443 lin ft, were made to obtain samples for analyses of the more than 40,000,000 cu yd of marsh mud encountered. Because of the variation in the character of the mud deposits, about 18,000 samples were tested for moisture content or density in order to classify the various strata. About 350 representative samples were tested for consolidation and permeability, and 175 for strength by triaxial methods at various stages of consolidation.

The studies of these tests, supported by past experience, indicated that it would be necessary to stabilize about 20,000,000 cu yd of mud and soft silt and clay to obtain rapid consolidation and settlement of the roadway embankments in the short period allowed for construction. All three methods listed above were used, but the third method was the principal one, utilizing about 5,000,000 lin ft of vertical sand drains which ranged from 12 to 100 ft in depth.

Sand-Drain Method Used Extensively

Previous work for the New Jersey State Highway Department on Route 3 at Secaucus, Route 35 at Point Pleasant, Route 100 in Linden and at other places had proved the efficacy of consolidation and stabilization of the subsurface material by the use of vertical sand drains. It was decided, therefore, that this method could be used successfully for the construction of the Turnpike across the Meadows.

Many possible alignments north of the Hackensack River in the vicinity of Laurel Hill were studied in an endeavor to locate the Turnpike where the mud was shallowest. Our subsurface explorations indicated that the Pennsylvania Railroad had years ago selected the best possible location and that we should parallel its alignment until the Turnpike turns northwest to cross the shallower marshes adjacent to the Secaucus Hills. The adoption of this alignment saved many hundreds of thousands of dollars over alternate locations previously considered which traversed the very deep mud deposits near the center of the New Jersey Meadows between the Secaucus Hills and the Lincoln Tunnel approaches.

The order of procedure used in the sand-drain method of consolidation on the Turnpike is shown in Fig. 2. In general, it was as follows:

NEW JERSEY TURNPIKE

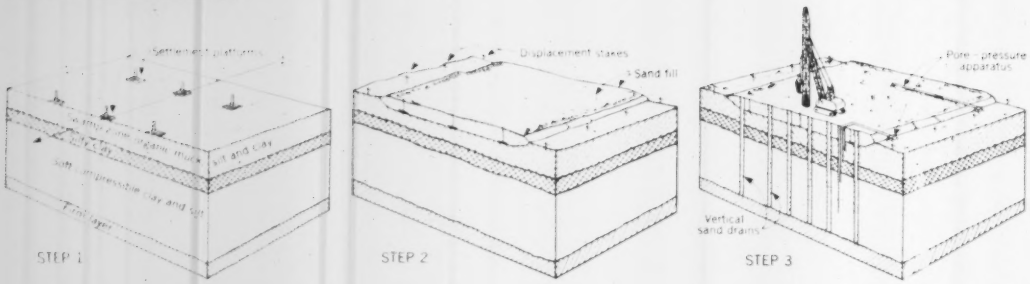


FIG. 2. SEQUENCE OF FILL STABILIZATION by vertical sand-drain method involved following steps: STEP 1: Settlement platforms are placed on original meadow surface. STEP 2: Porous sand fill is placed on meadow surface and displacement stakes are set. STEP 3: Vertical sand drains are installed through soft material up to 100-ft depth, and pore-pressure measuring devices are set at various depths. Remaining steps are illustrated on opposite page.

Step 1. To check the rate of stabilization during construction and to measure the amount of fill actually deposited for contract payments, 1,660 settlement platforms were installed before the blanket was placed. These platforms consisted of either a timber or steel plate rectangle, approximately 3 ft × 3 ft. To each platform a pipe was attached which extended upward through the fill. Extensions to this pipe were added as the fill was built up. At various elevations in the mud foundations, 450 pore-pressure devices were set up so that the effect of the fill load on the underlying strata could be closely watched. In addition, about 500 control stakes were placed at the sides of all fills, and in the meadow some distance from the toe of the fill, to indicate any sidewise movement. Such movement, if it became excessive, could develop into a mud wave, and cause collapse of the fill.

Step 2. A sand blanket 3 ft or more in depth was placed on the surface of the Meadow. The material composing such a blanket must be a free-draining sand containing a minimum of fine particles. The specifications for this blanket on the Turnpike required that 100 percent of the material pass the 2½-in. sieve; that from 60 to 100 percent pass the ¾-in. sieve; and that, of the material passing the No. 4 sieve, not more than 20 percent pass the No. 80 sieve, and not more than 2 percent the No. 200 sieve.

Because the material for the sand blanket lacked fines, it furnished a generally loose and unsatisfactory working surface for heavy equipment. Contractors were therefore permitted to deposit gravelly material containing up to 15 percent of fines on the blanket to a depth of from 1 to 2 ft, and to compact it sufficiently to form a working table for the sand-drain equipment. Some contractors placed mats on the sand blanket for their equipment rather than the finer material allowed by the specifications.

Step 3. With pile-driving equipment, a closed-end mandrel from 14 to 20 in. in diameter, as specified, was driven through the working table, the sand blanket, and the underlying Meadow material to a firm stratum. The mandrel was filled with sand and then gradually withdrawn while the sand was pushed out through the opened bottom of the mandrel by air pressure applied on top of the sand. Thus the air pressure held the sand in place in the hole while the mandrel was withdrawn. The sand-drain material was required to be free draining in character, even coarser than the sand blanket, but no large particles were permitted. Through these sand drains the water in the underlying material percolated upward to the sand blanket, as is shown in Fig. 3.

The depth to which the sand drains should be driven, and the amount of settlement to be expected in the underlying material, were estimated from previous subsurface explorations, including soil samples taken at several elevations. The depth to which the sand drains should be driven was again checked during the driving, and inspectors were instructed to have the driving continued until a specified number of blows per foot was required for penetration.

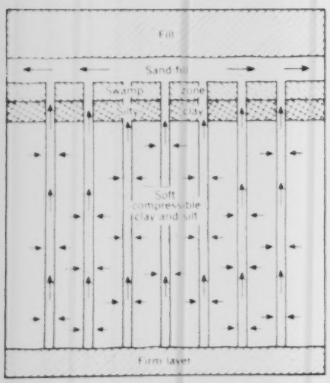


FIG. 3. VERTICAL SAND DRAINS to about 5,000,000 lin ft were driven into marsh formation in New Jersey Meadows section of route. Under load of fill water was pressed from compressible material and escaped through sand drains. In period of a few weeks, marsh settled to stable load-bearing condition.

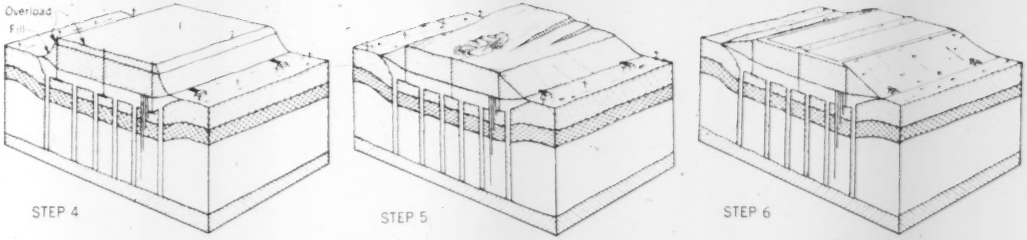


FIG. 2 (Continued). STEP 4. Overload material is placed in controlled increments, depending on gain in strength of marsh material as determined by readings of field instruments and soil laboratory tests. STEP 5. After consolidation, overload fill is removed and utilized to provide for future widening of Turnpike or to fill in service and interchange areas. Final stabilized roadway is shown in STEP 6. Pore-pressure devices and settlement platforms are left in place for permanent record.

Step 4. After completion of the sand drains, fill material was gradually deposited and compacted in thin layers on top of the working table. Close control of the placing of this fill was exercised, and if high pore pressures or excessive sidewise movement were observed, the placing of fill was temporarily discontinued until sufficient consolidation had taken place.

Fills were built up to the final profile grade, above which from 2 to 8 ft of overload fill was placed. In the vicinity of bridge abutments, where speed of consolidation was necessary, overloads of fill as high as 15 ft were used. At some locations fills as high as 60 ft, including overload, were placed on top of sand drains.

As the fill increased in height, its weight tended to compress the underlying material more and more, forcing the water from the mud into the sand drains, and then up into the sand blanket, whence it drained off into the adjacent meadows. After the fill reached the overload grade, in spite of the necessity of complying with the fast completion schedule for the Turnpike, a period of several weeks was insisted on in order to obtain stabilization of the underlying meadow mud. Longer periods were provided where possible, and would generally have been advisable had time permitted, to accomplish more complete stabilization and to reduce future maintenance costs.

The length of the stabilization period varied at different locations and was finally determined by continuous readings of the settlement platforms. For typical settlement curves, see Fig. 4, at right.

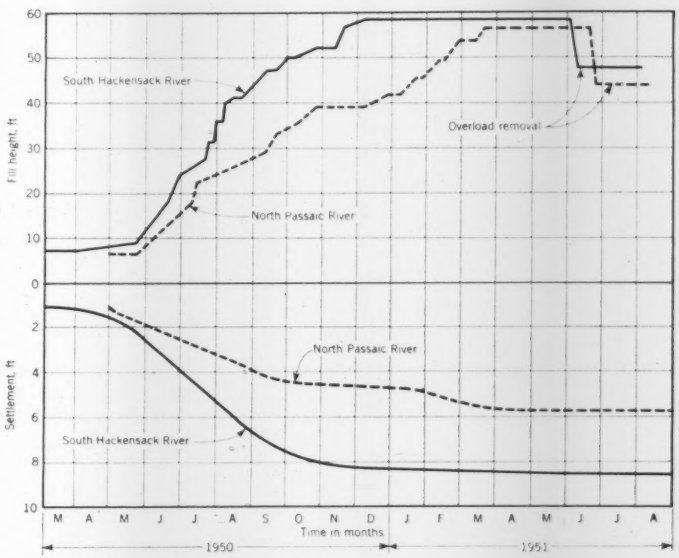
Step 5. When the settlement curves showed a definite tendency to flatten out, it was known that stabilization was nearing completion, and that the date for the safe removal of the overload, to allow for the construction of bridge abutments and paving, could be set. Settlement and pore-pressure readings were taken semi-weekly; they totaled over 100,000 readings. Pore pressures were closely watched to make sure that the superimposed fill was not being carried too largely on the water within the mud, a situation that would have caused blowouts and mud waves.

Step 6. After stabilization of the underlying strata and removal of the overload fill, the grade was ready for pavement construction.

Examples Show Good Consolidation

An interesting example of the consolidation effected by the sand-drain method is provided by experience at the old railroad yard at the Esso Standard Oil plant in Linden.

FIG. 4. CAREFUL READINGS of pore pressure and fill settlement, 100,000 in all, showed when settlement was about complete. Typical settlement curves are shown below.



Although the fill over this area had been in place for more than fifty years, and had carried continuous traffic during that time, when sand drains were driven and the fill and overload placed for the Turnpike, a settlement of 3½ ft occurred in a depth of mud of 15 ft or less.

Another striking example of the consolidation of the underlying meadow material, obtained by means of sand drains and overload, was furnished by a contractor's experience in building bridges across Paunpeck Creek and Bellman's Creek on the Turnpike north of Route 3. At each of these locations, the creek flow was diverted through temporary corrugated metal pipes, and the whole area surrounding the piers and abutments was given sand drain treatment. In driving the 14-in.-dia sand drains, once the sand blanket had been penetrated, one to five blows of the hammer per foot were required at both sites.

After stabilization, at Paunpeck Creek, the excavation was carried down to El. −20 ft inside a sheet pile cofferdam. Here the contractor experienced such difficulty in driving the sheetpiling through the consolidated material that he decided to substitute a well point system without sheetpiling at Bellman's Creek. At both locations 12-in. closed-pipe piles were driven with a No. 11 McKiernan Terry hammer to depths varying from 120 to 180 ft to support the bridge piers and abutments. The driving records show that from 20 to 25 blows per foot were required to penetrate the consolidated material.

North of Morse's Creek the Turnpike passes through the Standard Oil Company's refinery. As it was realized that this would be a difficult section, involving the relocation and construction of a new storage yard, it was the first contract let by the New Jersey Turnpike Authority. The successful bidder was Porter & McLane of New York.

In addition to stabilization of a considerable length of meadow underlying the refinery, up to depths of 25 ft, this job also required relocation and protection of numerous boat lines, several 60-in. salt water cooling lines, and various other utilities of the Standard Oil Company which, in their final location, would have to cross under the Turnpike. Uninterrupted operation of these pipelines was required to avoid a shutdown of the refinery. At this site sand drains to a total length of 198,800 lin ft were driven at a bid price of $1.00 per ft, and 500,000 cu yd of fill was hauled 46 miles by railroad, rehandled, and placed at a bid price of $1.60 per cu yd.

Between the Central Railroad of New Jersey crossing in Elizabeth and Raymond Boulevard, a distance of 5.85 miles, about 40 percent of the mud was shallow enough to be stabilized by laying an overloaded pervious blanket without any sand drains. At the crossing of three railroads, at a point known as the Oak Island Yard, this method was used with heights of fill exceeding 60 ft. On the remaining 60 percent of this section, sand drains 12 to 35 ft in length were required to stabilize the existing mud layers for the support of embankments ranging up to 40 ft in height. Most of the fills in this area were placed hydraulically up to a height of 65 ft by Construction Aggregates Corp. and Peter Kiewit & Sons Co. They attained a record rate of 750,000 cu yd in one month.

Some Cost Figures for Sand Drains and Fill

In this 5.85-mile length of the Turnpike, 867,000 lin ft of sand drains were installed on roadways and interchanges at an average price of 55 cents per ft, and 1,390,000 cu yd of fill were placed at an average price of $1.63 per cu yd. This fill was dredged from Jamaica Bay, Ambrose Channel and Sandy Hook and transported by dredges and scows to the basin in Newark Bay, whence it was pumped distances up to 17,000 ft to final location.

North of the Passaic River, very deep mud was encountered except in areas near Laurel Hill and short stretches in Secaucus. From the Passaic River to the Susquehanna crossing, a distance of 6.82 miles, the contractor was George M. Brewster & Son, of Bogota, N. J. His contracts involved the construction of 2,781,500 ft of sand drains at a bid price ranging from 40 cents per lin ft for the longer drains to 85 cents for the shorter ones, and the placement of 5,208,000 cu yd of dry fill at an average bid price of $1.57 per cu yd. This contractor made several progress records, among them the placing of 6,200 lin ft of sand drains with one rig in an eight-hour shift; and the placing of 997,000 cu yd of fill in one month using 300 trucks and ten shovels. Some of this fill was hauled 37 miles by rail, and truck hauls varied up to 25 miles.

North of Route 3 a layer of comparatively stiff material from 5 to 10 ft thick was encountered from 15 to 20 ft below the surface. Below this, soft silty material extended to great depths. To avoid great additional expense for driving sand drains 100 ft or more in depth, it appeared that low fills over this area could be carried on this substantial overlying crust. Only the material above this crust was treated with sand drains, and the grade through the area was raised from 1 to 2 ft to allow for possible settlement during the next fifty years. However, at bridge approaches the meadow was treated with sand drains to depths of from 70 to 100 ft. The same methods of treatment were applied to cross the deep mud beneath the ramps to the Lincoln Tunnel.

From the New York, Susquehanna & Western Railroad crossing to Route 6, a distance of 0.94 mile, layers of deep soft mud were encountered. This section also involved many difficult construction and stabilization problems to safeguard sewer lines, approaches to the railroad, the Overpeck Creek bridge, and traffic on Route 6 at the northerly interchange of the Turnpike. Stabilization on this section, involving 890,000 lin ft of sand drains ranging up to 100 ft in depth, at a bid price varying from 45 to 70 cents per lin ft, was completed by the Union Building & Construction Co., of Passaic, N. J., with the top record of 15,288 lin ft of sand drains driven with two rigs in two eight-hour shifts.

In the Passaic-Hackensack area, fills 40 ft high were built for bridge approaches. Based on contract prices, the cost of these fills, including sand-drain treatment, paving, drainage, and other facilities, was something less than $800 per lin ft of Turnpike. Adjacent structures, on the other hand, cost about $1,300 per lin ft.

Future widening of this section of the Turnpike to a dual-dual type will require the construction of a twin structure at an additional cost of $1,300 per ft, on the basis of present-day contract prices. However, future widening of the fill area for this purpose will cost only $400 per ft, since in the initial design provision was made, immediately adjacent to the structures, for a part of such future widening. This was done to avoid future placement of heavy embankment loads near the existing abutments. If this provision had not been incorporated in the design, the

cost of $800 per lin ft for the initial construction would have been considerably less.

The saving in both money and critical materials realized by using fills instead of structures would be even larger if fill material could be obtained at a lower price. On these projects fill averaged $1.62 per cu yd, with a range of from $1.20 to $1.85.

Embankment construction over the New Jersey Meadows, including the sections constructed by the New Jersey Highway Department, involved the placement of about 15,000,000 cu yd of fill. The quantities actually required were very close to the original estimates submitted to the New Jersey Turnpike Authority in September 1949, while the cost of the embankment work, including stabilization, was appreciably below those estimates.

Preliminary alignment studies over marsh land for Route 100 had been made by the New Jersey Highway Department from Woodbridge to Route 3. Much of the grading work was either completed or under contract from the Rahway River to Morse's Creek prior to the creation of the New Jersey Turnpike Authority. The preliminary engineering studies to determine the location and cost of the Turnpike from Bonhampton to the northern end were conducted for the New Jersey Turnpike Authority by Ammann & Whitney, Edwards & Kelcey, Frederic R. Harris, Inc., and O. J. Porter & Co. Their report recommended the incorporation of that portion of Route 100 between the Rahway River and Morse's Creek as a part of the New Jersey Turnpike, and this was done.

The engineering work for the design and construction of the roadways and interchanges of the Turnpike from Morse's Creek to Route 6 was done by Edwards & Kelcey, Frederic R. Harris, Inc., and O. J. Porter & Co. Grading, stabilization and pavement were assigned to the latter engineering firm with Mr. Porter, M. ASCE, as Assistant Project Manager and Mr. Urquhart, M. ASCE, as Assistant Chief Engineer in charge. The staff of the latter included J. E. Cowles as Contract Engineer on the northern section and L. J. Stephenson, M. ASCE, on the southern section. Resident engineers on the grading work between Elizabeth and Secaucus were K. S. Kelly and P. C. McCallum. Bruce McCreary, Assoc. M. ASCE, and R. S. Bodwell of O. J. Porter & Co., assisted with the design and supervision of the stabilization and grading work.

THIS SAND DRAIN RIG is typical of others used for placing drains through deep mud formations of Jersey Meadows section of Turnpike. With leads as high as 115 ft, mandrels up to 90 ft long were driven. Each hole was filled with sand, which was held down by air pressure while mandrel was withdrawn.

LARGE QUANTITIES of sand fill in Port Newark area were placed hydraulically. Sand was hauled from Atlantic Ocean shore areas by barge and dredge. Hydraulic fill was brought to construction site through pipes similar to one shown below.

NEW JERSEY TURNPIKE

Field construction controlled by soil

OF THE many astronomical figures involved in the conception, design, and construction of the New Jersey Turnpike, those summarizing the grading and embankment construction are among the most interesting. More than 16,900,000 cu yd of roadway earth excavation, 2,960,000 cu yd of roadway muck excavation and 22,460,000 cu yd of borrow excavation were handled by all types of excavating and hauling equipment. This equipment varied from tractor-drawn scrapers to the Euclid elevating loader capable of moving more than 1,000 cu yd per hour. Gigantic fleets of trucks were mustered for the longer hauls, and in some cases materials were delivered to or near the job site by rail.

The magnitude of these quantities, of course, early indicated the need for application of soil mechanics and foundation engineering principles to the project, despite the fact that many of the problems involved were fairly routine. The first investigations of soil conditions were made during the feasibility surveys. These studies roughly divided the project into two categories. The southern portion of approximately 95 miles traverses a terrain where the materials for excavation and embankment provided no abnormal problems of highway construction. In fact, many of the materials were well suited to highway construction. Similarly, little trouble with bridge foundations was anticipated in this part of the route. The northern section, however, traverses the low tidal flats and marshes known as the Jersey Meadows. These marsh areas, with soft deposits varying from a few feet to over 100 ft in depth, presented major problems in both road and bridge construction. The manner in which these specific problems were handled is treated in other articles in this issue.

As soon as a definite location was determined, borings were made at structure sites in each of the seven sections into which the route was divided for construction purposes. The borings were of both the dry-sample and undisturbed types, with the former predominating, and the information disclosed by these tests was immediately made available for the design of each individual structure. The structural foundations were of two types: spread footings and pile foundations.

For assistance during construction, a program was instituted in each section for highway borings, either of the auger or dry-sample type. Because of the special problems of stabilization under embankments, the highway borings in the marsh areas were more extensive than elsewhere and included some undisturbed sampling. The abundance of predominantly granular material and the proportionately small amount of clayey soils other than localized marsh deposits, made the design of embankments relatively simple. Where embankments crossed shallow deposits of muck in marshland or on the approaches to rivers and streams, the unsuitable muck was excavated and the foundation area backfilled with a sand having less than 10 percent fines passing the No. 200 sieve. Other embankment foundation areas, excluding the northern meadow marsh-

INVESTIGATION of more than forty embankment locations showed a few that required special stabilization treatment. Procedures varied from setting of stakes for control of lateral movement to installation of pore-pressure gages with controlled rates of loading. Thus danger of serious slides was largely eliminated.

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Soils Engineer

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samples tested in laboratory

lands, had the topsoil stripped and stockpiled. Areas under shallow embankments were then treated by in-place compaction to required densities.

There was little restriction of materials allowable for common embankment construction. With the normal exclusion of muck, peaty soil, and similar unstable materials, the only other restriction was applied to soils in the Public Roads Administration classifications A-6 and A-7. These clay soils were allowed in the embankment only in the side slopes outside a vertical plane from the top of the slope. Embankment slopes varied between 4:1 for fills shallower than 10 ft, to 2:1 for the higher fills. The back slopes of all cut sections had a maximum slope of 2:1. The specified conditions of placement for all common embankment materials were 6-in. layers loose measure, at 2 percent plus or minus variation from the optimum moisture content, and then compacted to 90 percent of the maximum density determined by laboratory analysis. The top foot of common embankment was required to be compacted to 95 percent of the laboratory maximum density.

The optimum moisture content and the laboratory maximum density were determined according to the modified standards of the American Association of State Highway Officials, as adjusted to the 6-in. mold generally associated with the California Bearing Ratio laboratory test. The purpose in specifying this size of mold was to accommodate the granular and soil-aggregate materials, which generally contained an appreciable quantity of particles larger than the No. 4 sieve. The only change from normal laboratory procedure necessitated by the larger molds was an increase in the number of blows of the 10-lb hammer to 55 per layer.

The negligible amount of rock excavation resulted in only one rock-fill embankment. This rock fill is in the middle of the northern marshes, on a stable foundation.

For a depth of 2 ft 4 in. above the common embankment, and above template grade in cut sections, two layers of select subgrade material were placed. The lower 1-ft layer, specified as Grade B Select Subgrade, was limited to not more than 10 percent passing the No. 200 sieve, a plasticity index of not more than 6, and a CBR of not less than 15 at 100 percent maximum density, saturated and soaked. The upper layer, specified as Grade A Select Subgrade, was limited to not more than 6 percent passing the No. 200 sieve, a plasticity index of not more than 3, and a CBR of not less than 20 at 100 percent maximum density saturated and soaked. These were described as pervious, free-draining, frost-resistant materials normally classified as A-3 by the PRA classification. For these materials to meet the requirement of being frost resistant, not more than 5 percent of their particles could be less than 0.02 mm in size. The source of these select subgrade materials was from both roadway and borrow excavation, and they were handled generally in the same manner as common embankment material, except that compaction to 95 percent of maximum density was required.

Field Laboratories Set Up

In order to obtain adequate control of these many specified characteristics during construction, each section engineer established a field laboratory. The laboratories were equipped to make all classification tests, gradation analyses, compaction determinations, and other associated determinations. Most of the laboratories, as a result of the earlier highway borings, had tested all the materials anticipated for embankment construction and had recorded their properties as a guide to facilitate the laboratory work during construction. Then as each material was disclosed by excavation, it was sampled, classified, and its compaction properties determined. It was necessary to perform this analysis coincident with the initial placement of the material in the embankment.

For the determination of field densities to check the field compaction specifications, the laboratories used all the common methods, such as heavy oil, calibrated sand and water-filled rubber membrane, for the volume determination. Some laboratories set up portable equipment in the field for moisture determination, while others performed such work in the laboratory. Although individual methods varied, all the laboratories, because of the vast quantities of materials moved each day, had to set up an organization and procedure for efficient and expeditious control of the construction.

It was the contractor's responsibility to locate all borrow pits, and when such pits were proposed for use for selected subgrade, the laboratory personnel sampled and analyzed the material for general conformity with the specifications. The approval of such a pit, however, did not relieve the contractor of the responsibility for material requirements. Therefore, during the placement of such materials, representative samples were obtained periodically and tested in proportion to the rate of placement. Once a source had been analyzed and accepted "as sampled" as

meeting the specifications for selected subgrade, the periodic checks during placement were limited to the determination of the percentage of particles passing the No. 200 sieve. This was done to expedite the work on the basis that the other required properties were principally functions of this value.

During construction, many materials used for common embankment that did not quite meet the gradation specifications for Grade B Selected Subgrade, while still meeting the other requirements, appeared to provide adequate drainage properties in the field. The question was raised as to why these materials were not suitable for selected subgrade. It was conceivable that materials not meeting the specification requirements with respect to the No. 200 sieve and the 0.02 mm particle size would provide the high-bearing value, free draining, frost resistant subgrade required. The specifications were designed to apply to the normal soil deposits in order to obtain the desired performance.

From earlier studies in frost resistance made at Purdue University, it was known that the effective quantity of particles finer than the critical 0.02 mm grain size for frost susceptibility is dependent upon the gradation of the total sample. It was also recognized that the effective quantity of particles passing the No. 200 sieve for a given drainage capacity was also dependent upon the gradation of the total sample. These facts, coupled with the requests for the use of substandard materials, started a study into the relationship between various gradation properties, permeability and capillarity for materials both passing and not passing the specification standards. It was not the intent of these studies to derive a new set of specification standards, but rather to arrive at a more specific understanding of relationships in order to determine whether individual proposed materials, not meeting specifications, were acceptable.

The gradation properties considered applicable were the percentage passing the No. 200 sieve, the percentage finer in size than 0.02 mm, the effective grain size, and the coefficient of uniformity. In the case of the two latter properties, the grain size distribution curves for the forty-odd samples tested indicated that a coefficient of uniformity based on the grain size for 70 percent finer and 20 percent finer, rather than the more generally accepted 60 percent and 10 percent finer values, provided a truer description of the material. The coefficient of permeability was determined by the falling-head method with varying densities, including 100 percent maximum density, for each sample investigated. The capillary potential was determined by the drawdown method as proposed by Jacob Mizroch of the Bureau of Public Roads, and the results obtained were considered for comparative purposes rather than as absolute.

The results of this series of investigations were far from complete, and no definite conclusions could be drawn. The sampling spread did not include a representation of all properties deemed pertinent. The results, however, did show that in all but a few cases samples meeting the specifications for a Grade B material exhibited a coefficient of permeability equal to or greater than 0.28 ft per day at 100 percent maximum density. This permeability value is essentially equal to 10^{-3} cm per sec, which is noted as the numerical limit between good and poor drainage by A. Casagrande, M. ASCE, and R. E. Fadum, Assoc. M. ASCE, in their chart of "Permeability and Drainage Characteristics of Soils."

The samples that met specification standards and exhibited coefficients of permeability less than 0.28 ft per day also exhibited correspondingly higher capillary potentials. All samples tested were so composed that the fines content was in direct proportion to the coefficient of uniformity. This eliminated studies of relatively dirty samples of uniform gradation and relatively clean samples with well-graded distribution. Because the studies were performed in conjunction with the construction of the project, it was not feasible from a time standpoint, to obtain or manufacture samples that varied from those available from the job site.

Although there appeared to be a marked permeability limit between samples above and below the 10 percent passing limit on the No. 200 sieve, the variations in drainage and capillary properties between the specified Grade A and Grade B Selected Subgrade materials tested were relatively small. The minimum limit of coefficient of permeability at 100 percent of maximum density for a Grade A material was about 0.5 ft per day. However, for the over-all types of granular materials investigated, there appeared to be a critical limit for the coefficient of uniformity, based on the 70 percent and 20 percent finer values of grain size, when compared to a given drainage capacity, for a decreasing fines content. Beyond this limiting value of approximately 10 for a comparable coefficient of permeability of 0.28 ft per day, and of approximately 7 for a comparable coefficient of permeability of 0.5 ft per day, the relative effect of a low fines content on the permeability appeared to have been considerably overestimated.

All substandard materials proposed during construction for substitution as Grade B Select Subgrade had coefficients of uniformity equal to or proportionately larger than comparable acceptable materials. As a result none of these materials was deemed acceptable because of their low permeability values at 100 percent of maximum density.

Because of the necessary transition of the roadway cross section between the embankment and paving phases of construction, the amount of Grade A Select Subgrade placed was in excess of that required under the ultimate paving. This material was excavated by "boxing out" the pavement section for the placement of pavement subbase and base courses, the excess material being utilized in building up the median strip and shoulders. This procedure resulted in a variable depth of Grade A Select Subgrade material under the pavement section, with approximately 10 in. at the pavement center line.

The specified CBR values of 15 for Grade B and 20 for Grade A materials were selected before any decisions had been made as to the ultimate type of pavement or the pavement design. However, these values were deemed adequate, since under a wheel load of 40,000 lb, the CBR of 15 would require a combined thickness of 15 in. above, and the CBR of 20 a combined thickness of 12 in. above. The ultimate pavement design resulted in an alternate proposal between rigid and flexible types, for a 36,000-lb axle load. The combined thickness of the rigid pavement was 16 in., and for the flexible design $18\frac{1}{2}$ in. Thus the bearing requirements for the selected subgrade materials were more than adequate.

In determining CBR values on selected subgrades, the minimum laboratory value on an acceptable material was approximately 22. This was for an extremely fine uniform sand just meeting specifications. As the work progressed it soon became apparent that, in general, acceptable materials encountered throughout the project exhibited CBR values much higher than the required minimum.

TURNPIKE STRUCTURE over Oldman's Creek rests on precast concrete piles and monotube abutment piles. Foundations for Turnpike structures were of two types—spread footings and pile foundations.

This limited the critical selection of subgrade materials to the primary investigation of their gradation properties, with the assurance that more than adequate bearing would be provided.

As a result of an exceptionally wet construction season during 1950, abnormally high ground-water conditions prevailed. In spite of a minimum side-ditch depth of 4 ft from pavement grade, many soft spots were encountered when paving operations commenced. This condition of saturated common embankment was also noted in some shallower embankments. These locations, primarily discovered by the specified pretesting of the subgrade, subbase and base courses, required the extensive use of porous concrete pipe for underdrains in order to assure adequate bearing for the ultimate pavement.

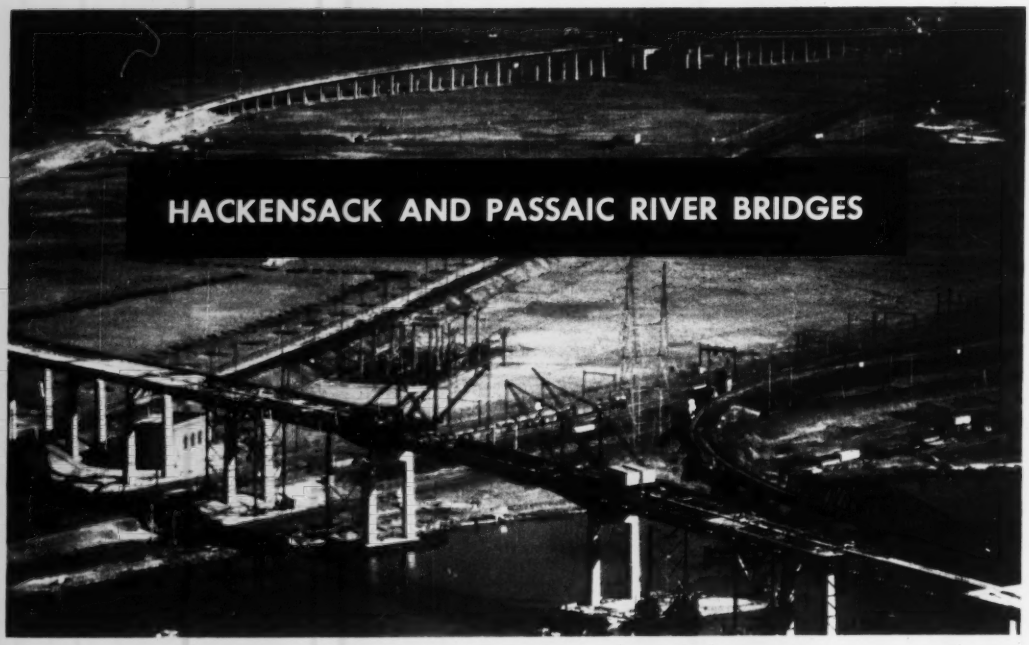
Another soil problem was presented with the slide of a 55-ft embankment on a river approach, which started a thorough study of all embankments on the Turnpike with respect to stability. The slide, which occurred in an area that had been previously thoroughly dredged of muck displaced approximately 50,000 cu yd of fill. Part of the muck had been removed in the dry by excavation from the shore, which had been carried down to a clay layer. This dry excavation disclosed the clay as a firm, relatively dry material. The remaining and greater portion of the muck was removed by a floating dredge from the river side. A granular backfill was placed in the dredged area to above high-water level, and the embankment of predominantly granular material constructed above it. The embankment was carried to the failure elevation within four weeks.

Borings in the failure area disclosed that the clay layer below the backfill was approximately 4 ft thick, with a moisture content varying from 50 to 100 percent by dry weight of soil, and having unconfined compressive strength ranging from 400 to 1,000 psf. Pore pressure measurements at approximately the center of the clay layer, taken immediately after the failure, indicated pressures varying from 26 to 60 ft of equivalent hydrostatic head. From the borings throughout the failure area it was not possible to discover any appreciable movement of the clay, and later only a small amount of disturbed clay was disclosed by cofferdam excavation at the front toe of the slope. This raised the question of whether the soft clay layer was responsible for the movement of such a large volume of material. It was suggested that a failure of small magnitude in the clay instigated a hydraulic failure within the embankment itself, due to a difference in permeability and density between the backfilled material and the compacted embankment, assisted by high pore pressures within the embankment.

The subsequent investigation of all embankment areas covered more than forty locations, with the exception of embankments in the northern marsh areas, which because of the special foundation stabilization procedures involved, were under constant critical surveillance. On the basis of field investigations and existing boring records, the greater part of these locations were classed as stable, requiring no further study or corrective measures. Some questionable locations were later classed as stable on the basis of additional borings, and only a few embankments required special treatment, which varied from the setting of stakes for control of lateral movement to the installation of pore pressure gages with controlled rates of loading. It is believed that the investigation and control measures eliminated the possibility of another such failure.

The various costs of earthwork quantities are summarized below. These prices were bid by the successful contractors, from February to July 1950, and are applicable to ordinary construction procedures according to the New Jersey Turnpike specifications. They do not include the prices for embankment construction over the marsh areas, where special materials as well as special construction procedures were required. Roadway earth excavation had an average unit cost of 39.7 cents per cu yd, with a maximum of 63 cents and a minimum of 33 cents. The average unit cost for borrow excavation was 56.5 cents per cu yd, with a maximum of $1.15 and a minimum of 35 cents. Both these items covered the costs of excavation, free haul for 6,000 ft, placement and compaction. In all but a few cases, borrow pits were readily accessible to the job site. The average unit cost for roadway excavation of muck was 63.6 cents per cu yd, with a maximum of 90 cents and a minimum of 30 cents, which included the excavation and hauling to waste areas, generally beyond the right-of-way.

Although the soil problems involved in the Turnpike project may have been somewhat routine, such an extensive field application of laboratory test results is seldom met with in soil mechanics work. Those connected with the soil program derived great satisfaction from the vastness of the program as well as from the continual challenge offered by the many different soil types encountered. It was a job requiring technical knowledge as well as organization to provide the necessary close coordination between the laboratory and the field.



HACKENSACK AND PASSAIC RIVER BRIDGES

Deck plate girders of record span adopted

O. H. AMMANN, M. ASCE

Ammann & Whitney, Consulting Engineers, New York, N.Y.

PLANNING and construction of the New Jersey Turnpike abounded in problems involved in overpassing and underpassing the numerous intersecting streams; tracks, yards and other railroad facilities; local streets and arterial highways; industrial plants, such as the extensive refineries of the Standard Oil Company in Linden; the Port Authority's Newark Airport; pipelines and other overhead and underground utilities.

These problems were especially difficult on the northerly part of the Turnpike which passes through densely developed residential and industrial sections of the cities of Elizabeth and Newark and crosses two major navigable streams, the Passaic and Hackensack Rivers. Within the 14-mile stretch from the south end of the crossing over the Rahway River to the northerly abutment of the Hackensack River Bridge, there are some 45 bridges and viaducts having a total length of about five miles, built at an aggregate construction cost of 45 million dollars.

In planning these crossings, it was essential to assure maximum economy of initial construction consistent with due regard to future requirements and to the safety and comfort of the traveling public. In the design of all bridges, whether seen from the Turnpike or from intersecting arteries or adjacent territory, good appearance was considered important. Therefore the Commissioners of the Turnpike Authority assigned a firm of prominent architects, Fellheimer & Wagner, to assist the engineers in producing structures that would be pleasing in line and form.

Simplicity of Design Stressed

The architects and engineers agreed that esthetic requirements would best be attained by simplicity in form and structural arrangement, by a clear expression of function, and by a certain uniformity throughout

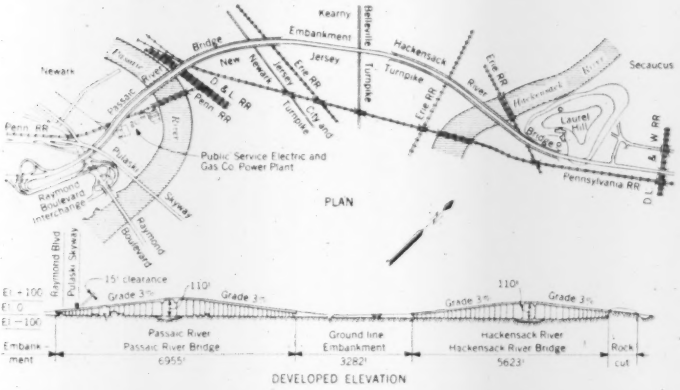


FIG. 1. ALIGNMENT of New Jersey Turnpike crosses over two rivers, numerous railroads and Pulaski Skyway within little more than two miles. Long curve at this location was necessitated by desire to cross railroads and Skyway at angle as close to 90 deg as possible.

TWO LARGEST structures on New Jersey Turnpike, containing longest single plate girders ever erected, are within two miles of each other. River spans for Hackensack and Passaic River Bridges each are 375 ft long, and provide 110-ft vertical clearance over rivers. Passaic River Bridge (foreground) is shown as closing sections of both girders are being placed simultaneously.

all the structures. In keeping with these aims unnecessary architectural embellishments were avoided, as well as all forms of trusses and conspicuous bracing. Likewise it was considered desirable to keep the carrying structure below the floor to permit an unobstructed view from vehicles passing over the Turnpike.

In general, short-span bridges, such as overpasses over streets, railroads and narrow waterways, were designed with plain rolled beam girders carrying the concrete deck on top. For a few exceptionally long spans and for high viaducts, riveted plate girders below the deck had to be used.

Piers and abutments were designed with plain concrete surfaces broken by grooved lines or form marks to relieve the monotony of large smooth surfaces. Stone facing of concrete was avoided, except on river piers near the water level.

The design of all structures which carry streets and highways is based on the Standard Specifications for Highway Bridges of the American Association of State Highway Officials and on the H20-S16-44 loading. Bridges carrying railroad tracks were designed in accordance with the requirements of the various railroads concerned.

The two major structures on the New Jersey Turnpike are the crossings over the Passaic and Hackensack rivers, both high-level bridges with long viaduct approaches. In the planning and general conception of their design, the two crossings had to be treated as a unit. On the selected Turnpike location, the two rivers are about two miles apart, and the alignments of the two crossings are therefore closely related (Fig. 1).

Both rivers are navigable. The requirements for shipping, width of channel and vertical clearances on each river called for approximately the same span arrangement and height of structure. Foundation conditions also appeared to be similar in character, although final subsurface investigations showed them in general to be more severe at the Passaic River crossing. The bridges are within the same section of the Turnpike as regards traffic capacity, initial and final.

Obviously this close proximity and similarity of physical conditions called for the same general type of structure at each site. Nevertheless there was ample opportunity for the exercise of independent judgment in the detailed design of the two bridges by the two engineering firms charged with the preparation of final plans, and in the fabrication and erection by two different bridge companies.

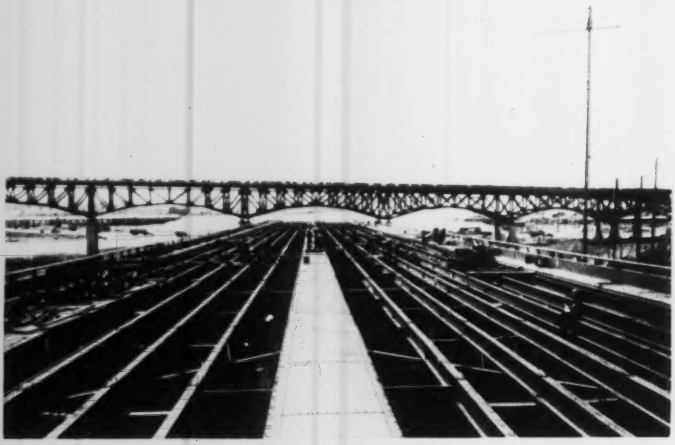
Alignment and Profile Prove Complex

Establishment of the alignment and roadway profile for the two crossings involved extensive alternate studies and cost estimates. The stretch of about three miles within which the two bridges and their viaduct approaches are located is crossed by numerous railroad tracks and yards, highways, industrial plants and utilities. Furthermore it was essential to plan the alignment with regard to the most practicable traffic interchanges north and south of this Turnpike section.

One of the pivotal obstructions at the southern end of this section was the Pulaski Skyway which, at the selected intersection with the Turnpike, is an elevated structure about 90 ft high, with deep main trusses. Studies made to find a means of bypassing the Skyway indicated that such bypassing would result in a more costly and otherwise undesirable alignment. It was therefore a question of passing either under or over the Skyway.

Going over the Skyway at an elevation of 120 ft above the ground would have involved long and expensive approach viaducts and would have made it very difficult to plan the interchange at Raymond Boulevard, south of the Skyway. With the adopted maximum grade on the Turnpike roadway of 3 percent it would, however, have been the only practicable solution if the War Department had required a clear height over the rivers of 135 ft. This height had been established at other crossings of the two rivers, both downstream and upstream.

Passing under the Skyway and over the immediately adjacent Raymond Boulevard was feasible with barely sufficient clearances, but permitted a fixed structure across the Passaic River with a clear height of not more than 110 ft at the channel lines. Available statistics of the traffic on the two rivers and informal inquiries addressed to shipping in-



SOUTH APPROACH of Passaic River Bridge (above) passes beneath deck trusses of Pulaski Skyway. Problem of alignment of Turnpike was complicated by numerous railroad tracks, utilities and industrial plants in this area. Economy dictated decision to go under rather than over the Skyway

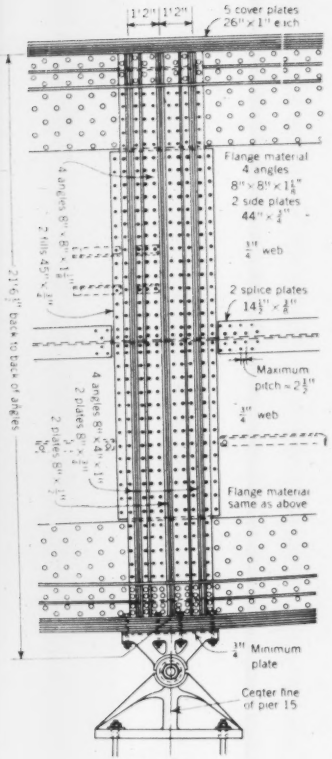


FIG. 2 (a)

tests indicated that a 110-ft clearance over both rivers might be acceptable. Alternate designs and cost estimates for both 135- and 110-ft clearances were therefore prepared for both bridges with fixed superstructures.

A study was also made for bridges with vertical lift spans providing a clear height of 70 ft in the closed position and 135 ft in the lifted position. This design proved to be somewhat more costly even than the highest fixed structure. For this reason, and because of the objectionable interruptions to the continuous flow of Turnpike traffic, and more costly operation, this design was eliminated.

Studies for the fixed, high-level designs were based on a structure with exceptionally long and deep continuous deck plate-girder spans. Consideration was also given to a tied-arch type of through span over the river channel. This would have permitted a shallower floor structure under the roadway and lower, less expensive, approach viaducts. However, like any through structure, it would have required wider and clumsier piers, would have formed an undesirable obstruction to a free view from the roadway because of the structure above the deck, and in its general appearance would not have harmonized with the adjacent approach viaducts, for which the deck girder type was most satisfactory and economical. Estimates indicated only a relatively small, if not questionable, saving in over-all cost in favor of a through span.

Before the Turnpike was financed, it was possible to obtain a ruling from the War Department on the clearances at both river crossings. At a public hearing in October 1949, recommendation was made for a 110-ft vertical clearance. There was practically no opposition, and the War Department approved this clearance, which definitely fixed the more favorable profile.

About 1,200 ft north of the adopted location of the Hackensack River crossing, an outcrop of traprock, called Laurel Hill, rises out of the marshland of the Hackensack Meadows. A Hudson County hospital is located on this rocky hill, which had a determining influence on the alignment of the Turnpike. Although involving a somewhat less direct alignment, Laurel Hill proved a natural and economical abutment for the northerly approach viaduct of the Hackensack River Bridge, making this approach viaduct about 1,000 ft shorter than the southerly approach viaduct of the same bridge and the two approach viaducts of the Passaic River Bridge. Moreover, the presence of traprock permitted relatively shallow pier foundations to bedrock for a considerable distance south of Laurel Hill. The Turnpike roadway skirts the easterly side of

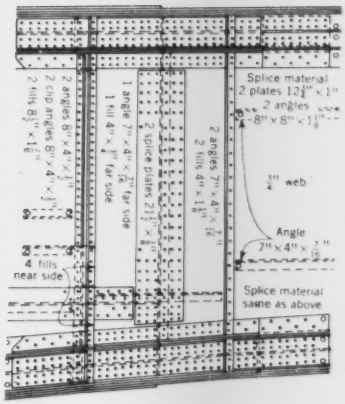

Splice material
2 plates 12" × 1"
2 angles
8" × 8" × 1"
web
Angle
7" × 4" × 7/16"
Splice material
same as above
4 fills
near side
2 fills 8" × 1"
2 clip angles 6" × 4" × 7/16"
1 angle 7" × 4" × 7/16" far side
1 fill 4" × 1" far side
2 splice plates 21" × 1"
2 angles 7" × 4" × 7/16"
2 fills 4" × 1"

FIG. 2 (b)

HAUNCH GIRDER for Passaic River Bridge (left) is lifted into position on north river pier. Details of bearing stiffeners and field splice for center section are shown in Fig. 2 (*a*) and (*b*) (facing page and above).

Laurel Hill and passes through a cut in the rock slope but does not interfere with the institution buildings.

On the adopted alignment, the angle at which the Passaic River is crossed is close to 90 deg. This alignment required a central river span 375 ft long in order to keep the river piers and their fenders clear of the 340-ft channel. For the two flanking spans a length of 275 ft was found most appropriate. The two main girders over these three openings are continuous and are cantilevered about 31 ft shoreward of the end piers, supporting at their ends the 189-ft simple-span girders which form the remainder of the 220-ft approach spans adjacent to the river spans. The girders thus have a total length of 987 ft.

Over the central part of each span the girders are 13 ft 3½ in. deep. For economy consistent with functional design, their depth was increased over the piers to 21 ft 6 in., a depth which involved a longitudinal splice of the web plates in that region (Fig. 2).

The Hackensack River Bridge crosses the river channel at a considerable skew, so that, although the channel is only 275 ft wide, the same central span of 375 ft was required to clear it. However, the length and arrangement of the adjacent spans and the depth of the girders differ somewhat from those of the Passaic River Bridge.

Longest Single Plate Girders

With a maximum span of 375 ft, these single plate girders rank at present as the longest of this type. The previous record, 330 ft, was held by the comparatively light girders of the lift span of the pedestrian bridge across the Harlem River, which was opened to traffic earlier this year. Several longer plate girder spans have been built in recent years in Germany, notably the 605-ft span of the bridge across the Rhine at Cologne, which replaced the suspension bridge destroyed in the last war. The girders of these German bridges are, however, of the cellular box type.

In developing the plate-girder design for the Passaic and Hackensack bridges, the designers realized the unusual problems involved in fabricating and erecting single girders of such length and depth. They therefore discussed these problems with competent fabricating and erecting concerns, who confirmed the practicability of the design. In fact these studies led to preliminary plans for a similar type of bridge which will carry a future extension of the New Jersey Turnpike across Newark Bay to Jersey City and will involve a channel span of 440 ft. This is probably the present practicable limit for this type of design.

Approach viaducts of both bridges range in height from 20 to 132 ft above ground. The deck is carried

throughout on pairs of simple span plate girders with span lengths ranging from 76 to 189 ft.

Economical Arrangement of Floor Structure

Numerous comparative studies were made to determine the most suitable and economical arrangement of the floor structure. This depended largely on the width of roadway to be provided in the initial and ultimate stages. The two bridges are located within the portion of the Turnpike for which an initial traffic capacity of 6 lanes and an ultimate of 8 lanes, or a dual-dual highway, was contemplated. Preliminary designs and cost estimates were therefore developed for both four-lane and six-lane initial structures.

In the final plans, each structure is provided with two 36-ft roadways allowing for an initial capacity of six traffic lanes with no provision for shoulders. It was assumed that if and when it becomes necessary to provide an eight-lane dual-dual highway, a duplicate structure will be erected. Each structure will then have a four-lane capacity and an extra lane on each roadway to provide adequate shoulders, a desirable feature on a long elevated structure. The two roadways on the initial structure are separated by a slightly elevated mall 6 ft wide. Outside of each roadway there is a slightly elevated, open-grating, service and emergency walk, and a substantial box-type steel parapet with a pipe railing on top. This resulted in a total width of structure of 86 ft.

The economic and esthetic advantages of the deck plate girder design, as compared with any type of through structure, is due largely to the possibility of placing the main girders entirely under the floor, thus permitting the most economical arrangement of the floor structure and comparatively narrow, graceful piers (Fig. 3).

For the Passaic River Bridge, a distance between main girders of 47 ft 10½ in. was adopted, with a cantilever overhang of the floor structure of about 19 ft on each side. In the Hackensack River Bridge the arrangement differs somewhat in that the distance between girders is 56 ft and the overhang 15 ft (Fig. 4).

In the preliminary plans, comparative designs and cost estimates were made for both steel and reinforced concrete piers. The available insufficient information on subsurface conditions indicated that because of their lighter weight, particularly on the deep pile foundations, steel piers might be somewhat less expensive. A review after full boring data became available led, however, to the final adoption of the obviously more economical slender reinforced concrete type of pier.

For the Passaic bridge, the higher piers consist of two concrete shafts which, with concrete struts at top and bottom, form a rigid frame. The lower piers consist of only the two concrete shafts.

The major part of the two crossings passes over the marshy ground of the Hackensack Meadows. For the preliminary location and design studies, soil and rock profiles were obtained from available information on existing structures and from a limited number of new borings. From this information it was evident that no satisfactory soil stratum was available and that all pier foundations had to be carried to bed rock. In this section bed rock is at an average level of about 80 ft below the ground surface and at a maximum revealed depth of about 120 ft.

This rock is the red sandy shale which underlies much of the northeastern part of New Jersey. It is rather friable when exposed, but possesses considerable load-bearing capacity when confined beneath deep overburden. The material overlying the rock consists in general of a shallow meadow mat of peat resting on a deep, variegated deposit of silt, soft clay and fine sand, which offers no excessive resistance to the driving of piles yet is sufficiently firm to assure the lateral stability of pile foundations.

With the exception of the two river piers of the Passaic River Bridge, and a number of piers at the northerly end of the Hackensack River Bridge approach in the vicinity of Laurel Hill, all piers are founded on clusters of partly vertical, partly

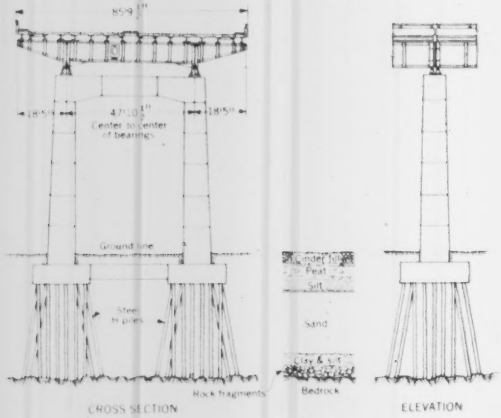
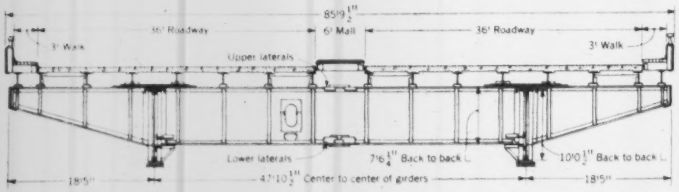


FIG. 3

FIG. 4



PASSAIC AND HACKENSACK Bridges are structurally similar although full duplication was impracticable. Piers for both structures are slender reinforced concrete, pentagonal shafts (Fig. 3). High piers have concrete struts top and bottom, omitted on low piers. Transverse section (Fig. 4) is of Hackensack River Bridge. Passaic Bridge differs in minor details.

battered, steel H-piles of lengths up to 107 ft.

At the Passaic River the rock surface was found to be between 40 and 45 ft below low water level, or from only 20 to 25 ft below the bottom of the river. It was therefore advisable to carry the bases of these piers down to rock. At the Hackensack River Bridge approach near Laurel Hill, where rock is close to the surface, the piers are likewise founded directly on rock.

Total Bridge Lengths and Costs

The total length of the Passaic River Bridge with its approach viaducts is 6,955 ft and that of the Hackensack River Bridge, 5,623 ft. Their costs of construction were respectively $13,700,000 and $9,500,000—an average of $1,971 and $1,681 per lin ft, or $22.92 and $19.55 per sq ft of floor area. The greater cost of the Passaic River Bridge is due to its greater length, less favorable alignment, severer foundation conditions, and more interference with construction by railroads and utilities. Approximately 60,000 tons of steel and close to 100,000 cu yd of concrete were used in the two bridges.

Both bridges will be completed and ready for traffic in January 1952, or about 25 months after final planning was started. This establishes a record for the planning and construction of a structure of this type and magnitude, considering the heavy demand for manpower and materials stimulated by national defense activities.

The design work and field supervision required the closest collaboration with the Authority staff, and with each other, by the three engineering organizations mentioned in the next two paragraphs.

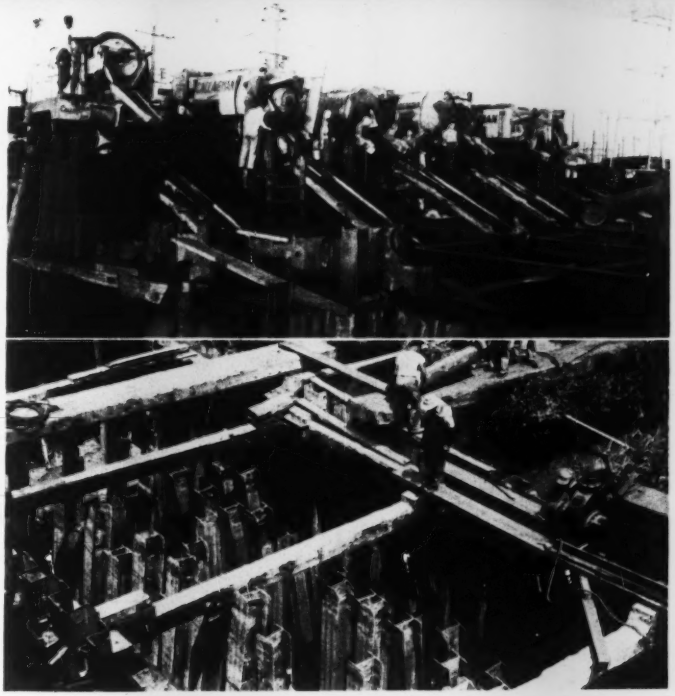
Development of the final plans and construction supervision were in charge of Howard, Needles, Tammen & Bergendoff for the Hackensack River Bridge, and of Ammann & Whitney for the Passaic River Bridge.

Edwards & Kelcey, Frederic R. Harris, Inc., O. J. Porter & Co., Associated, Engineers for the grading and paving work on this section of the Turnpike, were charged with the establishment of the alignment and grades.

The major construction contracts were most creditably carried out by the following contractors:

On the Hackensack River Bridge: river piers and foundations by R. B. Jaggard Engineering Co., approach piers and concrete deck by Cayuga Foundation Corp., steel superstructure by the American Bridge Company.

On the Passaic River Bridge: river piers and foundations by Underpinning & Foundation Co., approach piers by George M. Brewster & Son, Inc., steel superstructure by the Bethlehem Steel Company, and concrete deck by Johnson, Drake & Piper.



CONCRETE for Passaic River pier N-2 (top view) is poured from six transit-mix trucks at one time. Tight schedule necessitated such high-speed methods. Lower photo shows steel piles for pier N-2 of Hackensack River Bridge, which are both vertical and battered. Piles were driven in dewatered cofferdam.

Structural Committee of New Jersey Turnpike Authority

Member	Firm
Ellis E. Paul, M. ASCE, *Chairman*	Howard, Needles, Tammen & Bergendoff
William J. Delaney	New Jersey Turnpike Authority
Henry C. Tammen, M. ASCE	Howard, Needles, Tammen & Bergendoff
Milton G. Brumer, M. ASCE	Ammann & Whitney
H. J. Williams, M. ASCE	Fay, Spofford & Thorndike
T. C. Frederic, M. ASCE	De Leuw, Cather & Company
E. W. Fickenscher, Assoc. M. ASCE	Edwards & Kelcey, Frederic R. Harris, Inc., O. J. Porter & Company
Alfred Hedefine, M. ASCE	Parsons, Brinckerhoff, Hall & Macdonald
Allston Dana, M. ASCE	Gannett, Fleming, Corddry & Carpenter, Inc.
J. J. Jenkins, Jr., M. ASCE	J. E. Greiner Company

HACKENSACK AND

ELLIS E. PAUL, M. ASCE

Howard, Needles, Tammen & Bergendoff

Consulting Engineers, New York, N.Y.

SPEED of construction of Hackensack River Bridge is illustrated by two photographs taken a year apart. In September 1950 (photo at right) work on river piers had begun and swampy area in rear had been filled in to provide access to approach pier sites. By September 1951 (photo on facing page) all piers were completed and traveler was erecting final spans of south approach.

SEPTEMBER 1950

Design, fabrication and erection

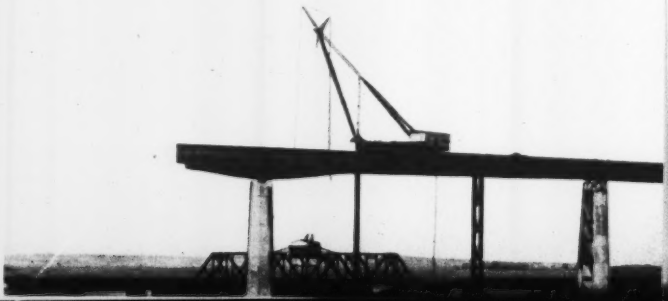
NOT ONLY do the Hackensack and Passaic River Bridges contain the longest plate girder spans ever built in this country, but considering the width of roadway and the dead and live loads carried, they compare favorably with the largest girder spans ever built. Their design presented all the problems encountered in the design of other Turnpike bridges besides special problems of unusual interest.

Time a Major Consideration

Before discussing the special design and construction features of these two bridges, it is of interest to mention the time element. Preliminary studies and engineering reports indicating the feasibility of the entire Turnpike were submitted on September 15, 1949, after the unprecedentedly short time of four months.

To further illustrate the effect of the time element on the design, the schedule of dates for receiving bids is presented: main river piers, February 1, 1950; approach piers, April 1, 1950; superstructure (except roadway deck), May 1, 1950. It must also be realized that at least three weeks was allowed between the date of advertising and the date for receipt of bids. Thus the first contracts had to be ready to submit to bidders within $3\frac{1}{2}$ months after instructions were received to proceed with the design of the Turnpike as a whole.

When instructions to proceed were received, no final borings had been made and the final alignment had not been established. This preliminary work was of course started immediately and by mid-November had progressed sufficiently to permit final designs to be made. It was not until November that approval was obtained from the Department of the Army on the final vertical clearances for the two bridges over the Hackensack and Passaic Rivers. In the meantime the engineers had made



NORTH APPROACH of Hackensack River Bridge abuts on rock outcrop of Laurel Hill. Photo shows traveler in August 1951, just after it had erected upper half of fish-belly section over north river pier.

complicated by size of members

many studies and preliminary designs to determine economical span lengths, girder spacings, cross sections, depths of girders, pier sections and all other details that had to be determined before final designs could be undertaken.

Full Duplication Not Feasible

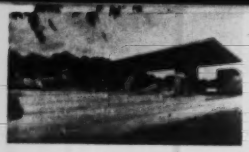
During the period of preliminary studies, the two firms held a number of conferences on the subject of using duplicate details for the two bridges. It soon became apparent that, everything else being equal, the time element alone would not permit full duplication. In addition, special design problems to meet clearances at points such as railroad crossings and power stations, made it impractical to use the same spacings of girders. From discussions with the two principal steel companies, considering the large quantities of steel involved and the short time for fabrication and erection, it appeared likely that all the work could not be handled by one company, and therefore that no benefit would be realized from duplications in fabrication. This conclusion was borne out by the bidding, since bids for both superstructures were received at the same time, and bidders were given the opportunity to bid on one or both of the contracts and thus to indicate any savings that might accrue as the result of taking both contracts. No such saving was indicated. Since full duplication was not possible, both engineering firms exchanged their preliminary ideas and studies of economic span lengths, cross sections, etc., for such use as might be helpful in securing the desired uniformity of appearance, and then proceeded with the final designs to meet their individual problems and the time schedule that had been set up.

The foundations followed general design outlines and presented no difficulties. To assist in the construction of the foundations, a low embankment fill, about 100 ft wide, was placed along the full length of the meadow area. This embankment furnished access to all pier sites and space for storage of materials and equipment, besides generally consolidating the mat area and adding stability to the ground around the pier bases.

Steel Piles Chosen After Extensive Study

A very extensive study was made of the comparative economy of using wood piles, steel H-piles, and cast-in-place piles. Because of the great depth to rock in places, especially along most of the Hackensack River Bridge, it would have been necessary to obtain a large part of the wood piles from the West Coast. The steel H-piles, with their greater carrying capacity, would permit the use of smaller footings with a minimum of reinforcing steel and indicated appreciable economy over the other types studied. Designs were based on the carrying capacities given in the AASHO Specifications, and the steel piles used were designed to carry 50 tons of dead load plus live load and a maximum load of 75 tons under all loads, including 50 psf for wind, temperature, traction, etc. Special steel points were provided to give adequate and suitable bearing on the shale, taking into account the eccentricity of the load from bearing on uneven rock

Before deciding finally on steel piles it was necessary to determine whether there were any stray earth currents that would create a corrosion hazard to steel piling, and if so, whether such conditions could be overcome satisfactorily. A preliminary report, received in mid-December from Albert F. Ganz, Inc., indicated the presence of electrical stray-current gradients in the earth having fluctuating direct-current railroad load characteristics. These gradients were thought to be due primarily to



the combined effects of the direct current operation of the joint Hudson & Manhattan Pennsylvania line between New York and Newark, and of the electrified division of the Delaware, Lackawanna & Western Railroad.

In addition, this investigation indicated the probable presence of galvanic cell action in the soil, which would influence the corrosion rate of steel piles. This condition was later verified by separate chemical analyses of soil samples taken from various depths, and as a result additional metal was added to the piles.

The Ganz report stated the opinion that, from the standpoint of stray-current corrosion, steel H piles could be used with safety provided the design of the piers incorporated certain recommended precautionary measures briefly as follows:

1. Remove all organic meadow mat and peat, together with any cinder fill, unburned carbon or other chemically waste material, wood forms, etc., from contact with the steel piles.
2. Keep all steel piles metallicly isolated from each other and from the steel superstructure.
3. Keep a minimum of 3 in. between steel piles and reinforcing steel and between reinforcing steel and steel anchor bolts of the superstructure steel.
4. Use steel piles with a cross-sectional area at least 10 percent in excess of what would be normally used to meet structural and load requirements.

Since the corrosion from electrolytic action occurs on the side of the pile away from the direction of flow of the electric current, the design assumed loss of metal on one side only, and gave full consideration to the resulting eccentricity of the section. The piles were designed to be safe for all design loads for more than 100 years, using the maximum rate of loss as determined from the tests, and assuming that the current would be flowing continuously. Under these assumptions, the pile cross-section adopted was approximately 20 percent above that required for normal load requirements. Even with this excess metal, steel piles were found to be the most economical type.

Probably the largest continuous plate-girder bridge previously constructed in this country is the Charter Oak Bridge, crossing the Connecticut River at Hartford, Conn. This bridge is a similar three-span unit with end spans 270 ft long and a center span 300 ft long, and is designed for two traffic lanes in each direction. The two Turnpike bridges have end spans of practically this same length but their center spans are a quarter again as long, and their traffic capacity is 50 percent greater. The problems of fabricating, transporting and erecting the Turnpike bridge girders were consequently many times greater than those for the largest similar structure previously constructed.

Maximum economy was a primary objective of the design, and the controlling feature of girder dimensions in this respect is naturally the depth. However, individual phases of the over-all construction, such as weight of metal, fabrication, transportation and erection presented diverging requirements. A certain minimum depth was needed to produce a size and form of flange which not only could be fabricated by normal plant equipment but which also would avoid the necessity of excessively long rivets with their consequent decreased strength.

The flange areas required can be visualized from the design moments, which were a maximum of 44,000 ft-kips in the end span, 123,000 ft-kips at the intermediate pier, and 62,000 ft-kips in the center span (Fig. 1). In the final design the largest flange area was 263 sq in. gross of silicon steel as compared with 163 sq in. gross of the same material for the Charter Oak Bridge.

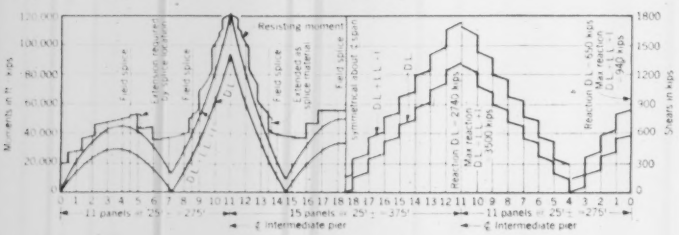
Besides economy, another factor involved in the choice of girder depth was the deflections that would result. These had to be well within those permitted by the rigid specifications and the best modern practice. The type of girder that gave most promise of meeting all these various requirements was a box girder or a pair of girders erected singly and field connected by diaphragms. This type is much stiffer horizontally and torsionally and therefore easier to handle and erect. However, before a final decision was reached, careful studies were made to determine the relative economy of box girders—which would eliminate horizontal field splices—and single web plate girders.

Two constant-depth box girders were designed—one 12 ft $2\frac{1}{2}$ in. back to back of angles, and the other 13 ft $8\frac{1}{2}$ in. back to back of angles with 60-in. cover plates. From the standpoint of economy alone, these box girders were too shallow over the interior piers, requiring much more flange area than the single web girder, and too deep at the centers of the spans. Variations in the depth of the box girder would have somewhat reduced the amount of steel but would have increased fabrication costs.

The insurmountable difficulty in obtaining economy in a box girder is largely due to the impossibility of providing two web plates which will be at the same time sufficiently thick to avoid buckling near the compression flange and not excessively thick to carry the shear. An additional drawback of the box girder was the greater number of field splices required to limit the weight of erection pieces to that for the single web girder. Comparative estimates, verified subsequently by independent estimates made by the largest fabricating companies, revealed that while the pound price of a double-web girder would have been less than that of the single-web girder, the total cost would have been greater.

To achieve the most economical single-web girder, the two largest fabricating companies were consulted as to the maximum depth, length and weight of individual girder sections that could be fabricated, shipped and erected. On the basis of the advice received, more refined designs were prepared and conferences again held with the fabricators to obtain

FIG. 1. ON Hackensack River Bridge, maximum moment at intermediate piers was 122,000 ft-kips, which required a maximum flange area of 244 sq in.


Resisting moment
Field splice
Intervals changed by splice location
Extended as span material
Symmetrical about ℄ span
D.L.
D.L. + L.L. + I
Reaction D.L. = 274 kips
Max reaction D.L. + L.L. + I = 1500 kips
Reaction D.L. = 450 kips
Max reaction D.L. + L.L. + I = 940 kips
Moments in ft-kips
Shears in kips
11 panels @ 25′ = 275′
15 panels @ 25′ = 375′
℄ intermediate pier

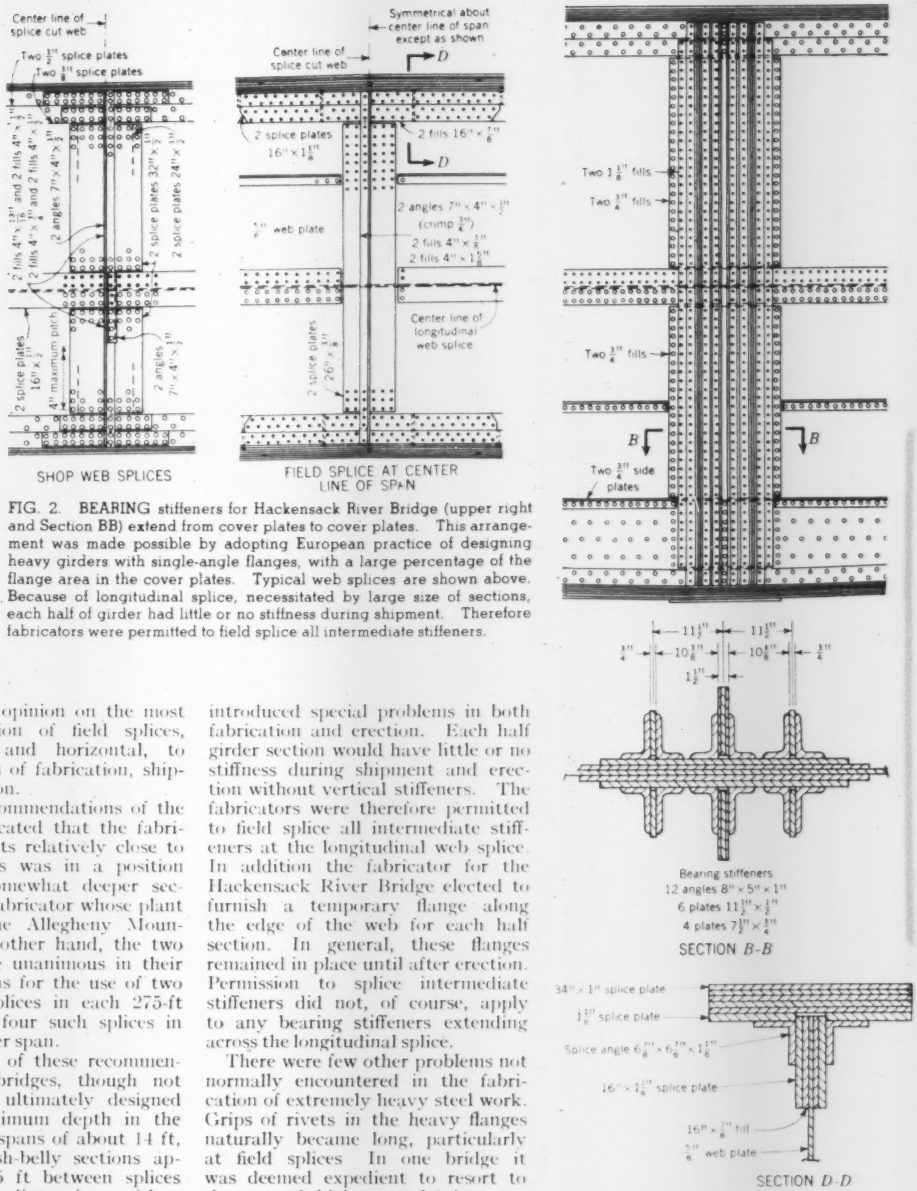

Center line of splice cut web
Two $\frac{3}{4}$" splice plates
Two $\frac{3}{8}$" splice plates
2 fills 4" × 13" and 2 fills 4" × $\frac{7}{16}$"
2 fills 4" × $\frac{7}{16}$" and 2 fills 4" × $\frac{3}{8}$"
2 angles 7" × 4" × $\frac{3}{8}$"
2 splice plates 32" × $\frac{3}{8}$"
2 splice plates 24" × $\frac{3}{8}$"
2 splice plates 16" × $\frac{3}{8}$"
4" maximum pitch
2 angles 7" × 4" × $\frac{3}{8}$"
SHOP WEB SPLICES
Symmetrical about center line of span except as shown
Center line of splice cut web
2 splice plates 16" × $1\frac{1}{8}$"
2 fills 16" × $\frac{7}{8}$"
D
D
$\frac{5}{8}$" web plate
2 angles 7" × 4" × $\frac{3}{8}$" (crimp $\frac{1}{4}$")
2 fills 4" × $\frac{3}{8}$"
2 fills 4" × $1\frac{1}{8}$"
Center line of longitudinal web splice
2 splice plates 26" × $\frac{3}{8}$"
FIELD SPLICE AT CENTER LINE OF SPAN
Two $1\frac{1}{8}$" fills
Two $\frac{3}{4}$" fills
Two $\frac{3}{4}$" fills
B
B
Two $\frac{3}{4}$" side plates
$11\frac{1}{2}$"
$11\frac{1}{2}$"
$\frac{3}{4}$"
$10\frac{3}{8}$"
$10\frac{3}{8}$"
$\frac{3}{4}$"
$1\frac{1}{2}$"
Bearing stiffeners
12 angles 8" × 5" × 1"
6 plates $11\frac{1}{2}$" × $\frac{1}{2}$"
4 plates $7\frac{1}{2}$" × $\frac{3}{4}$"
SECTION B-B
34" × 1" splice plate
$1\frac{1}{2}$" splice plate
Splice angle $6\frac{7}{8}$" × $6\frac{7}{8}$" × $1\frac{1}{8}$"
16" × $1\frac{1}{8}$" splice plate
16" × $\frac{7}{8}$" fill
$\frac{5}{8}$" web plate
SECTION D-D

FIG. 2. BEARING stiffeners for Hackensack River Bridge (upper right and Section BB) extend from cover plates to cover plates. This arrangement was made possible by adopting European practice of designing heavy girders with single-angle flanges, with a large percentage of the flange area in the cover plates. Typical web splices are shown above. Because of longitudinal splice, necessitated by large size of sections, each half of girder had little or no stiffness during shipment. Therefore fabricators were permitted to field splice all intermediate stiffeners.

a consensus of opinion on the most desirable location of field splices, both vertical and horizontal, to meet conditions of fabrication, shipment and erection.

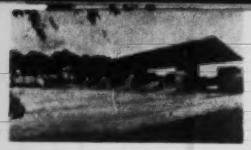
The final recommendations of the fabricators indicated that the fabricator with plants relatively close to the bridge sites was in a position to transport somewhat deeper sections than the fabricator whose plant was beyond the Allegheny Mountains. On the other hand, the two fabricators were unanimous in their recommendations for the use of two vertical field splices in each 275-ft end span, and four such splices in each 375-ft center span.

On the basis of these recommendations, both bridges, though not identical, were ultimately designed to have a maximum depth in the end and center spans of about 14 ft, secured with fish-belly sections approximately 125 ft between splices over the intermediate piers, with a maximum depth overall of about 22 ft 6 in. The recommended number of vertical field splices was adopted, resulting in a maximum shipping length of about 130 ft and a maximum shipping weight slightly in excess of 100 tons (Fig. 2).

The use of horizontal field splices introduced special problems in both fabrication and erection. Each half girder section would have little or no stiffness during shipment and erection without vertical stiffeners. The fabricators were therefore permitted to field splice all intermediate stiffeners at the longitudinal web splice. In addition the fabricator for the Hackensack River Bridge elected to furnish a temporary flange along the edge of the web for each half section. In general, these flanges remained in place until after erection. Permission to splice intermediate stiffeners did not, of course, apply to any bearing stiffeners extending across the longitudinal splice.

There were few other problems not normally encountered in the fabrication of extremely heavy steel work. Grips of rivets in the heavy flanges naturally became long, particularly at field splices. In one bridge it was deemed expedient to resort to the use of high-strength rivets at splices.

The most desirable distribution of the cross sectional area of the flanges of the girders is affected by several factors. With four angle flanges, the inner pair of angles are not as effective as the same area would be in a cover plate. Moreover, the vertical stiffeners are interrupted at the inner angles and probably are not as effective as they would be if one pair of flange angles were used so that the stiffeners could be lapped over the vertical legs of the flange angles. Past experience with four-



angle flanges has been satisfactory, and this objection to their use is probably minor. Wide cover plates are somewhat easier to splice than narrow ones. Elimination of the inner flange angles, by widening the cover plates, results in a minor saving because less steel is required and fewer pieces are needed. Wide cover plates provide greater transverse strength, which is highly advantageous in handling and erecting long girder sections.

American specifications normally limit the percentage of flange area in the cover plates. The desirability of this specification for ordinary bridges is unquestioned but it has apparently little theoretical justification. A study of European plate girders revealed a number of bridges that depart greatly in this particular from normal American standards of design. Two European spans over 300 ft long have an area of cover plates equal to about $\frac{4}{5}$ of the total flange area, giving the highest ratio ever used as far as we were able to determine. However, there are other European bridges which approach this high ratio, and studies revealed five bridges that have more cover-plate area than the Turnpike bridges.

After a thorough study of the problems involved, the design of the Hackensack River Bridge was made to follow more along the line of European practice, using two angle flanges with 34-in. cover plates. The 258-in.-deep web plate is 1 in. thick and is reinforced with longitudinal stiffeners composed of two 6 x 4 x $\frac{3}{8}$-in. angles. The designers of the Passaic River Bridge decided to follow the more conventional American standard, using four angle flanges with 26-in. cover plates and a web 258 x $\frac{3}{4}$ in., reinforced with one 8 x 4 x $\frac{1}{2}$-in. longitudinal stiffener angle.

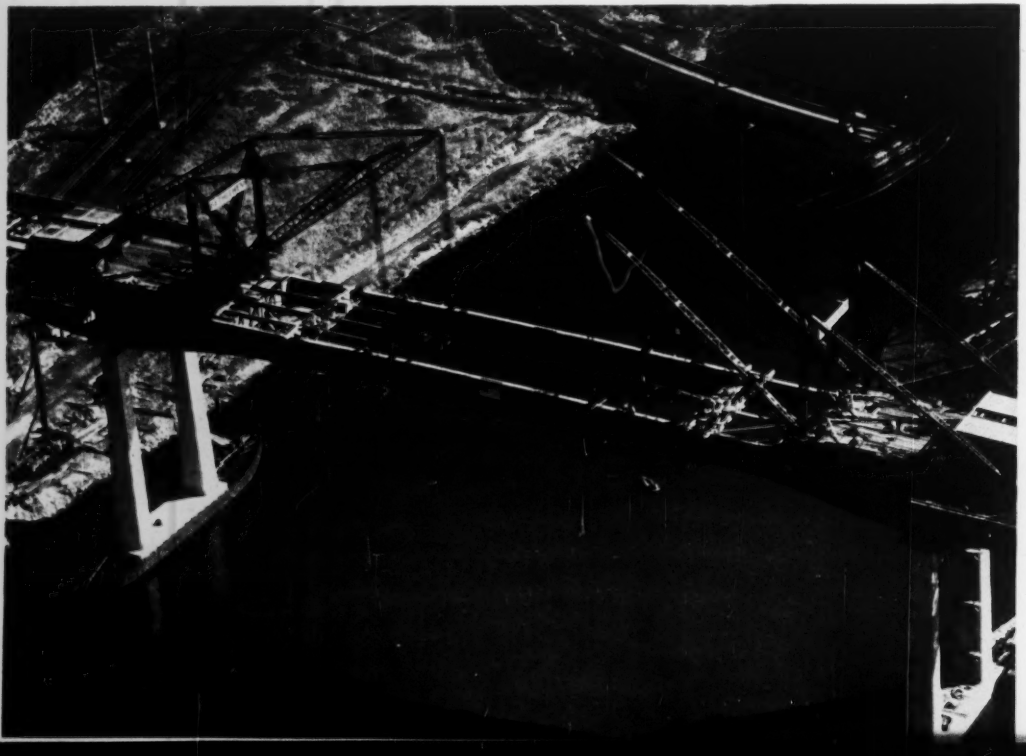
Since the girders themselves have little torsional strength, and a cross section with two girders and one plane of lateral bracing offers little resistance to torsion, two planes of lateral bracing were provided. During erection of the center span, torsional loads of considerable magnitude were imposed on the structure, and the second lateral plane was especially useful at that time.

Erection Problems Solved

In heavy girder work, erection problems revolve primarily around the related considerations of weight of members to be handled, location of field splices, and use of falsework. On both bridges erection of the main river-span girders was performed by travelers running on the bridge girders, to which the steelwork was delivered largely by barges. For the Hackensack River Bridge, one traveler with a capacity of 100 tons was used, erecting to the splice point short of the center line of the center span. The traveler was then dismantled and re-erected on the other side of the river for erection of the remainder of the span from that end. For the Passaic River Bridge two travelers, each with two booms having a confirmed capacity of about 200 tons, were used, erecting simultaneously from each end.

On the Hackensack River Bridge, all end and center-span girder sections, shipped in upper and lower halves, were assembled prior to erection and raised as single units. In the case of the sections over the central piers, the lower and upper halves, averaging slightly over 90

TWIN-BOOM travelers erected closing sections of both girders of Passaic River Bridge simultaneously. Sections had been floated to site by barge.



tons each, were erected separately. Auxiliary bearing stiffeners were furnished to receive the reaction prior to placing of the permanent, full-length stiffeners.

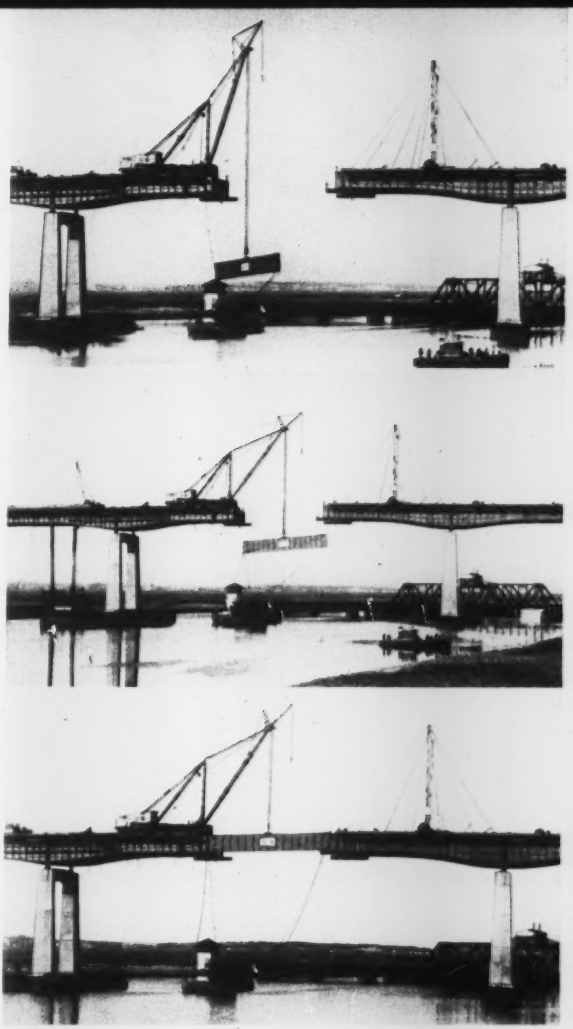
On the Passaic River Bridge, the upper and lower halves of each central-pier section were completely assembled, and the resulting 172-ton section was raised by both booms of the traveler.

The erection procedure on both bridges required the placing of a temporary steel bent at each splice point of the end spans. Since splices are not located at points of contraflexure, the height of bents was carefully adjusted to bring the splice points to their no-load, cambered elevation. The splices were riveted while the girders were under a condition of nominal stress. Thus the theoretical outline of the end spans was retained as far as possible.

Since navigation requirements prohibited the use of falsework under the center span, cantilever erection became a necessity. Under these conditions of erection, the ends of the two cantilevers would sag well below the final elevations in the three-span continuous structure. Furthermore the tops of the cantilevered girders would be too close together, and the bottoms too far apart, for insertion of the closing section. It was therefore necessary to rotate each of the two cantilevered plate girders in a vertical plane about the pins of the shoes on the two central piers to bring their outer ends to the same elevation and into a vertical plane.

To assure longitudinal clearance for insertion of the closing section under a range of temperatures, it became necessary to pull back one of the two cantilevers. Vertical rotation was produced by removing the shoes on the end piers, lowering the ends as necessary to bring the cantilevered ends to the desired vertical and angular positions, and by furnishing temporary supports for the spans in place of the shoes that had been removed.

With the outer ends of the two cantilevered sections at the same elevation and practically vertical, and with the distance between these ends such as to provide a slight erection clearance, the span was ready to receive the central, closing sections of the girders. Since jacking had to be performed simultaneously on both girders of each section, temporary bracket supports (shown in photos on this page) for the closing sections were provided on the ends of the two cantilevered sections. The two closing sections were then landed on these bracket supports, and the cantilevered sections were jacked longitudinally to close with the central section and jacked vertically at their outer ends as necessary to match the splice holes. Splice material was then erected and completely fitted up under a condition of practically zero stress. Next, the outer ends of the central sections were jacked so that the temporary bracket supports could be removed. Finally, the girders were replaced on their permanent shoes.



CLOSING SECTION of Hackensack River Bridge was erected by single-boom traveler. First, closing section was lifted from barge (top). Then it was hoisted into position (center), and finally it was rested on special temporary brackets (bottom). Jacks at outer ends of both north and south spans pivoted cantilevered girders around river piers and moved them longitudinally so that splice holes matched.

Much credit for the design work and construction supervision is due to the following key personnel: Milton Brumer, M. ASCE, Werner Ammann, M. ASCE, L. H. Just, and Roy F. Wheadon, Assoc. M. ASCE, of Ammann and Whitney; and Charles H. Clarahan, Jr., M. ASCE, J. Henry Leon, and L. D. Brown, M. ASCE, of Howard, Needles, Tammen & Bergendoff. I also wish to express my deep appreciation to Mr. Clarahan and Mr. Leon, who were most helpful in preparing data for this article.

Flexible-type

SECOND COURSE of asphaltic concrete is spread on penetration macadam base by Barber-Greene equipment on Section 2 of Turnpike.

THE FIRST meeting of the engineering firms engaged by the New Jersey Turnpike Authority was called by Charles M. Noble, M. ASCE, Chief Engineer of the Authority, in October 1949 and was attended by representatives of all the section engineers, the consulting engineers, and the Turnpike engineering staff. The question uppermost in everyone's mind at that time was whether the Turnpike would be black or white. A very preliminary discussion indicated that if the thirty engineers present were each to select a type, there would be thirty pavements, no two of which would be identical. It is truly amazing that such a wide divergence of opinions can exist on such an important engineering problem. It shows that the engineering profession is as open minded as ever on this matter.

The Authority had requested the advice of its engineers as to the type of pavement that would stand up best under extremely heavy truck loads and insure good and economical service for the life of the Turnpike bonds. It was apparent that many meetings and frank exchanges of knowledge, experience and opinions would be needed to prepare a satisfactory design. To accomplish this, the New Jersey Turnpike Paving Committee was formed, consisting of one man from the office of each section engineer and one from the office of the consulting engineer. The personnel of the Paving Committee is shown in the box on page 76.

The committee was charged with two principal tasks: (1) to develop a typical grading section which could be used immediately on the grading and drainage contracts and which would be suitable for whatever type of pavement was eventually chosen; and, (2) to develop designs for both a rigid and a flexible pavement suitable for use on the Turnpike.

The committee was advised that parts of the Turnpike were to have a 24-ft and parts a 36-ft roadway on each side of a 26-ft center dividing strip, with a 16-ft shoulder on the outside, 10 ft of which was to be improved, and a slope of 1 on 4 beyond the shoulder to a low point a minimum of 5 ft below the finished pavement grade. This section would provide a ditch of ample depth to drain the subgrade.

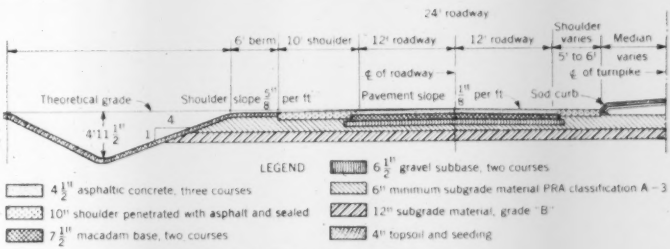
The first step was relatively easy. In the course of two or three meetings, a section acceptable to all concerned was selected and the grading plans for the Turnpike were rushed to completion.

The chosen section required excavation of all materials to 36 in. below the finished pavement grade. From 36 to 24 in. below grade the backfill was to be a pervious frost-resistant material having not more than 10 percent passing the 200-mesh sieve, having a plasticity index of not more than 6 and a California Bearing Ratio of not less than 15 percent. From 24 to 8 in. below the finished grade the backfill was to be a pervious, frost-resistant material having not more than 6 percent passing the 200-

JOHN R. DIETZ, Assoc. M. ASCE

Chief, Highway Division
Gannett, Fleming, Corddry & Carpenter, Inc., Engineers
Harrisburg, Pa.

pavement selected



TYPICAL HALF SECTION, NEW JERSEY TURNPIKE

FIG. 1. FLEXIBLE asphaltic concrete pavement 12 in. thick was adopted on basis of bid price $5,100,000 lower than that for rigid concrete pavement 10 in. thick.

mesh sieve, a plasticity index of not more than 3, a California Bearing Ratio of not less than 20 percent, and conforming to the P.R.A. Classification A-3. The finished grading section was 8 in. below grade at the center line, with a 2 percent cross slope for temporary drainage prior to paving. Material from 3 ft to 4 ft below the finished grade was compacted to 90 percent of the modified AASHO standard; above that to 95 percent. This applied to both cuts and fills.

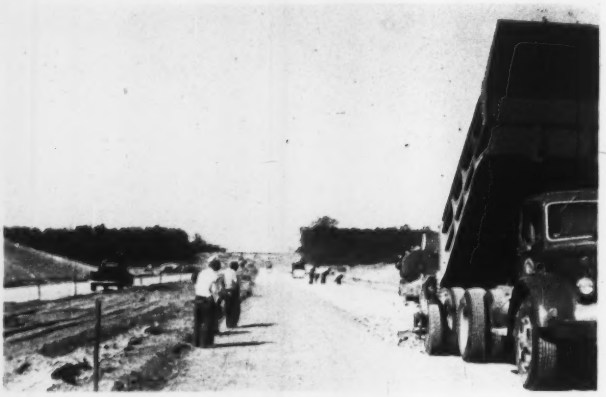
The second task proved more difficult and required many hours of reviewing the literature and data furnished to the committee by various interested parties, followed by meetings to discuss this material. The Portland Cement Association, the Asphalt Institute, various officials of New Jersey, Pennsylvania, Massachusetts, and other state highway departments, contractors and material producers were all helpful and supplied the committee with much of its basic data.

The first problem was to choose a suitable design load. A study of loadometer tests in New Jersey showed that axle loads of more than 45,000 lb might be expected on the Turnpike. New Jersey laws were not too clear on the maximum legal load, and legislation was pending which would restrict the loads and bring them more in line with those permitted in surrounding states. This pending legislation provided a five-year change-over period in which the trucking industry might convert its equipment. Thus it was considered necessary to have a design load in excess of the 22,400-lb axle load contemplated in the new laws, but less than the 45,000-lb axle loads occasionally encountered, which were expected to become less frequent under the new legislation. A compromise axle load of 36,000 lb was finally recommended by the Committee and agreed on by the Authority.

Designs were developed both for a flexible pavement and for a rigid pavement as follows. The flexible pavement design consisted of a 6-in. pervious non-frost-active subbase; two 3-in. layers of waterbound-macadam base course; a 2-in. layer of penetration-macadam base course; and $4^1/_2$ in. of asphaltic concrete surface course. The asphaltic concrete was to be laid in a $2^1/_2$-in. binder course and a 2-in. surface course. Side forms were to be used to insure a sharp edge on the pavement and a smooth riding surface. The 6-in. subbase was specified to consist of well graded crushed rock, slag, or gravel of a durable and frost-resistant character. It was felt that such a choice would encourage the use of local materials and would be economical. Grading requirements were specified to insure a material that could be compacted and still be sufficiently porous to drain well. The 6-in. depth was to be placed in two layers to insure maximum compaction.

The base course, which was designed to consist of two 3-in. layers

NEW JERSEY TURNPIKE



FIRST COURSE of macadam stone is placed on compacted, frost-resistant subbase. Macadam was bound with penetration asphalt using 3.2 gal of asphalt per square yard of 7½-in. subbase.

of waterbound macadam and a 2-in. layer of penetration macadam, is the equivalent of many secondary roads throughout the East. Crushed stone or crushed gravel fully choked with screenings was specified for the waterbound base. For the 2-in. penetration course, crushed stone was specified, using from 1.6 to 1.8 gal of asphalt per sq yd. Sufficient chips to fill the surface voids were to be added while the bituminous binder was still liquid. A rubber tired roller weighing 25,000 lb per wheel was specified for compacting the top course of the waterbound macadam, in addition to the conventional rolling of each individual layer.

The asphaltic concrete was designed to consist of a 2½-in. leveling or binder course and a 2-in. surface course. These were to be a plant mix and hot laid. A tack coat was specified for the macadam base course before the leveling course was placed.

The adequacy of the flexible pavement to support the design load was checked by various methods such as the design charts prepared by the Corps of Engineers, the symposium of flexible pavement design published by the American Society of Civil Engineers in January 1949, and the prevailing designs in use by nearby state highway departments.

A Rigid Pavement Also Designed

The so-called rigid pavement design recommended by the committee consisted of a 10-in. thick standard-type portland cement concrete pavement on a 6-in. pervious subbase, all supported by the compacted selective subgrade previously described for the flexible pavement. The 6-in. pervious subbase design was substantially the same as that specified for use under the flexible pavement. The details of the slab design were briefly as follows.

Control joints were to be spaced 78½ ft center to center and were to consist of treated, clear sound lumber ½ in. thick, extending from the bottom of the slab to within ¾ in. of the top of the slab. A rubber latex joint filler was specified for watertightness. Round steel dowels 1¼ in. in diameter spaced on 12-in. centers were used to transfer the loads across the joints. These dowels were to be of a corrosion resistant metal or with equivalent protection, held firmly in a rigid frame and meeting the performance specifications of the New Jersey Highway Department.

Reinforcement was to average about 5½ lb per sq yd of pavement sufficient to prevent cracking of the slabs and was to be placed between 2 and 3 in. below the surface. More steel was to be used in the middle third of the slab length than near the ends.

Construction could be either in 12- or 24-ft lanes at the option of the contractor, the lanes to be tied together by ½-in. round tie bars 30 in. in length, spaced 26 in. on centers. A screw or lock type of tie bar of equal strength could be used.

Air entraining cement was recommended in a mix containing 6 bags of cement per cu yd. A 1-in. maximum slump was specified. Preliminary finishing was to be kept at a minimum to prevent bringing excessive fines and mortar to the surface. Brooming was recommended to obtain a non-skid light-reflecting finish.

The adequacy of the design to take the assumed design loads was checked by the methods set forth in *Concrete Pavement Design*, published by the Portland Cement Association in 1946, using a K value of 150. There was such a wide difference of opinion as to the proper K value to use that a value was finally decided on by taking the average of the recommendations of the various committee members.

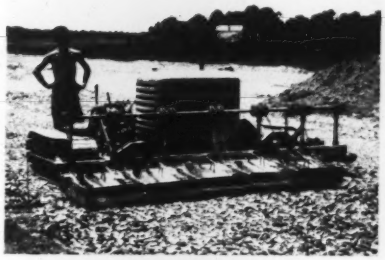
Three Types of Shoulders Studied

Shoulders should be able to support, at infrequent intervals, the heaviest trucks using the Turnpike. They should provide a seal to keep water out from under the roadway pavement, and they should have a different appearance from the main pavement to discourage their use as a regular traffic lane. Three different designs were prepared by the committee, as follows. Where a high intensity of very heavy traffic was anticipated, a 10-in. depth of shoulder consisting of 7 in. of subbase material topped by 3 in. of penetration macadam was recommended. This is a high-type shoulder, quite expensive, and would be used only in special cases.

The second design, for locations where a moderate intensity of heavy traffic was anticipated, called for a compacted thickness of 10 in. of subbase material with a double bituminous surface treatment.

The third shoulder design consisted of a 10-in. compacted thickness of pit-run gravel or crusher-run

SMALL CRAWLER VIBRATOR (below) consolidates base stone. At right, choke stone is rolled into penetration macadam subbase.



FIRST COURSE of asphaltic concrete is spread and rolled near North Camden Interchange. Altogether, 3,900,000 sq yd of Turnpike pavement was laid.

stone. The second shoulder design, calling for a double bituminous surface treatment, has been used throughout most of the Turnpike.

Authority Decides to Take Alternate Bids

The Pavement Committee suggested four choices to the Authority. These were as follows:

1. Pave with rigid-type pavement. Cement was readily available in the five southern sections at costs not subject to appreciable variation. Aggregates would be readily available at reasonable cost if competitive conditions were present. The rigid pavement requires slightly more labor than the flexible type and would make this item somewhat less expensive in Sections 1, 2 and 3 than in Sections 4 and 5 by reason of a slight difference in the rates for common labor. Furthermore the greater labor supply in the three southern sections and more freedom from jurisdictional disputes favored greater efficiency and decreased cost of portland cement concrete there.

2. Pave with a flexible-type pavement. Sections 6 and 7 over the marsh area at the northern end probably will settle somewhat for a long period and for that reason the flexible pavement was considered to be preferable there. Asphalt was readily available in the remaining five sections and was not subject to appreciable fluctuations in cost. Aggregates were readily available in Sections 4 and 5, but in Sections 1, 2 and 3, considerable importation would probably be necessary. The

WITH asphaltic pavement in place, Apsco spreader places gravel on inner shoulder, followed by wobble-wheel roller, in farming country on Section 1.

NEW JERSEY TURNPIKE

labor conditions were similar to those mentioned for rigid pavement, but would be effective to a lesser degree.

3. Pave with both types. This scheme would involve the maximum use of locally available material and facilities, and would utilize the widest variety of construction equipment. A reasonable place to change the type of pavement would be at the Raritan River, with rigid pavement to the south and flexible pavement to the north. The committee was unanimous in having no objection to the use of more than one type of pavement on the Turnpike.

4. Take alternate bids. This method probably would result in the lowest pavement cost and introduce the greatest competition into the bidding. The Authority was advised that the initial cost of pavement was not the total cost but that the award of contracts on any other basis than the initial cost would not be an easy matter.

The Turnpike Authority decided on the fourth choice—to take alternate bids. Accordingly, contract plans were prepared for both types of pavement and duly advertised. The bid prices totaled approximately $40,300,000 for bituminous concrete versus $45,400,000 for portland cement concrete, or a difference of $5,100,000 for the 3,900,000 sq yd of pavement involved. After all the bids were received, the Authority awarded the paving contracts for flexible pavement (Fig. 1).

Shortly after the award of these contracts, Savin Construction Co., the successful bidder in Section 2, made a proposal to substitute an asphalt penetration base course for the waterbound macadam base course specified. The proposal was that 7½ in. of penetration base be placed in two layers instead of the 8 in. of macadam base consisting of 6 in. of waterbound macadam and 2 in. of penetration macadam. The ½-in. differential in depth was to be made up by increasing the thickness of the subbase from 6 to 6½ in. The contractor offered a total of 3.2 gal of asphalt cement per sq yd in the base course and a credit of 10 cents per sq yd on the price of the pavement.

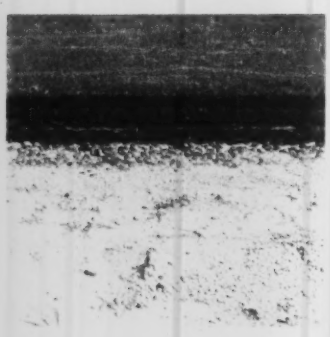
The use of a penetration base had been discussed at various times by the Pavement Committee. At a general meeting of the committee with the Authority engineers in May 1950 it was decided that the waterbound courses were entirely adequate to support the design loads, and based on the cost figures which the committee had, the waterbound base was less expensive than the penetration base. Within a short time, however, the remaining successful bidders on the pavement contracts made similar requests to the Turnpike Authority. Eventually it was decided to use the asphalt penetration base throughout the Turnpike.

The pavement contractors made another request which the Turnpike Authority accepted, with the concurrence of its engineers and the Paving Committee. Side forms had originally been specified, but the contractors offered to place the 4½-in. depth of bituminous concrete in three courses instead of two courses as specified, if the side forms could be eliminated. The contractors agreed that the elimination of the forms would in no way alter the requirements of the specifications regarding the line, grade and riding qualities of the pavement.

The asphalt penetration base provided the contractors with an excellent haul-road as soon as their first layer of stone had been penetrated and choked, thus greatly expediting the construction work. For various reasons, many of the grading and drainage contracts got behind schedule, and it would have been difficult to complete the pavement in the time available if the original design had been adhered to.

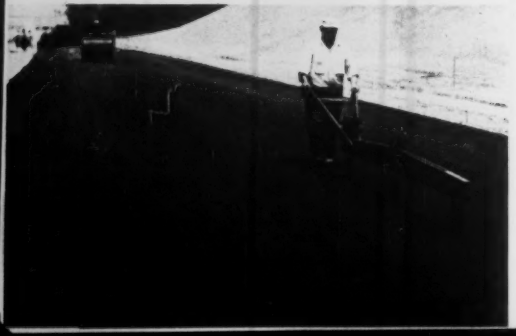
Paving Committee of New Jersey Turnpike Authority

Member	Firm	Section
O. J. Porter, M. ASCE, Chairman	Edwards & Kelcey, Frederic R. Harris, Inc., O. J. Porter & Co.	6-7
Elmer K. Linder, M. ASCE, Vice Chairman	Howard, Needles, Tammen & Bergendoff (Consulting Engineer)	
J. K. Knoerle, M. ASCE	J. E. Greiner Co.	1
John R. Dietz, Assoc. M. ASCE	Gannett, Fleming, Corddry & Carpenter, Inc.	2
Douglas R. Sayer	Parsons, Brinckerhoff, Hall & Macdonald	3
C. E. DeLeuw, M. ASCE	DeLeuw, Cather & Co.	4
W. T. Hyland	Ray, Spofford & Thorndike	5



THIRD COURSE
SECOND COURSE
FIRST COURSE

THREE COURSES of asphaltic concrete are clearly visible in this photograph. Originally two courses with side forms were specified. Contractors agreed to place 4½-in. depth of bituminous concrete in three courses if side forms were eliminated.



SMOOTHNESS OF PAVEMENT was checked by three-wheeled indicator. If center wheel moved up or down more than specifications allowed, bell rang and spot was marked for rerolling.

ASPHALTIC CONCRETE PAVING for Sections 3 and 4 of Turnpike was supplied by four Madsen batching plants (two shown above) with 4,000-lb pug mills. Each plant could produce 125 tons per hour, and four batching plants established record production of 6,200 tons of hot-mix asphaltic concrete in single day. These plants, located at Cranbury, produced asphaltic surface course for 45 miles of Turnpike.

Construction of asphaltic concrete pavement carefully controlled

LESLIE M. STEWART, Special Bituminous Consultant, New Jersey Turnpike Authority, Trenton, N.J.

AFTER the pavement bids were received and the decision made to utilize asphaltic concrete for the Turnpike pavement, meetings of the Turnpike Authority engineers and their consultants were held to arrange a program for the design of mixes and adequate engineering control of this phase of construction.

Since the entire Turnpike project was divided into seven sections, each under the direct supervision of a nationally known engineering organization, it was the problem of the Turnpike engineers, assisted by their consultants, to arrange a program for paving work such that, on all seven sections: (1) the design of mixes would be similar; (2) the methods of controlling the mix would be adequate and practical; (3) control of paving methods would be similar and such that contractors would be able to proceed at a rapid pace; and (4) paving inspection would be adequate to keep to a minimum, areas in need of correction or repair.

To accomplish these aims a meeting was held in Trenton at which the engineers and inspectors on all seven sections were briefed to familiarize them with the plans for construction and control of the paving work. Discussions were presented on each phase of the operations so that those engineers not wholly familiar with asphaltic concrete could acquaint themselves with this type of construction, while those more experienced could assist the others and enlarge their own knowledge.

The terrific traffic load to be carried by the Turnpike complicated pavement design. The strength and stability of a bituminous concrete roadway depend directly on the construction of the entire pavement cross section from the subgrade to the finished surface. For the Turnpike, it was necessary to secure a pavement capable of: carrying axle loads of 36,000 lb; resisting expansion and contraction; providing the maximum practicable traction for fast moving rubber-tired vehicles; supplying a surface texture that would be practically the same on all seven sections; and meeting requirements for riding quality of the highest order.

These considerations demanded an asphaltic concrete sufficiently stable in the lower courses to withstand loading, and sufficiently flexible to withstand variable weather conditions. They required a wearing surface constructed with the necessary flexibility, laid to provide smooth riding, but also with a texture to resist skidding.

The section engineers investigated all surrounding areas for local materials that could be utilized. In the southernmost sections of the Turnpike satisfactory dolomitic rock was available for coarse aggregate and in the northern sections trap rock was available. Sands for fine aggregate were found in most sections. Generally however, the fine and coarse sands had to be blended to obtain the desired gradation. Varying amounts of fillers could be added where needed, and the various section engineers, with the assistance of their bituminousconsultants, prepared preliminary mixes and made preliminary tests to determine the desired mix.

The tests used for determining approval of the various design mixes were generally: a stability test to

NEW JERSEY TURNPIKE

TABLE I. AVERAGE SIEVE ANALYSIS OF MATERIALS USED FOR ASPHALTIC CONCRETE PAVEMENT

Sieve Size	Leveling Course Mix, % Passing	Wearing Course Mix, % Passing	New Jersey Turnpike Specifications, % Leveling Course Mix	New Jersey Turnpike Specifications, % Wearing Course Mix
1-in.	100	None	100	None
3/4-in.	95	100		100
1/2-in.	63	72	50-70	60-80
No. 4	38	44	32-46	40-52
No. 8	32	38	25-36	30-42
No. 30	22	24	16-26	15-25
No. 100	6	6	5-12	6-12
No. 200	3	3	1-5	2-6
Asphalt cement (added)	4.9	5.6	4.5-5.5	5.0-6.5

determine strength by the Marshall test; a flow test to determine flexibility; a percentage-of-voids test to determine density and asphaltic content; and a gradation test to determine surface texture.

The total thickness of 4 1/2 in. of bituminous concrete was to be placed in three 1 1/2-in. courses—two leveling courses, and a top wearing course. The largest particle size of coarse aggregate allowed was 1 in. for the leveling courses and 3/4 in. for the wearing surface. Results of tests by the section engineers were studied by the writer, and some changes were made to give uniformity in all sections before the mixes were approved and the paving started.

The mix designs approved for the seven sections were quite similar in appearance and texture although they varied somewhat in physical characteristics. The average extractions and gradations for leveling and wearing courses were approximately as shown in Table I.

The average characteristics of the mixes from all sections were approximately as given in Table II.

The greatest difficulty was to obtain a gradation of aggregates that would give the desired stability, flow, and texture, and at the same time have sufficient voids so that the pavement would expand and contract normally under variations in temperature. The mixes were designed so that after heavy construction traffic had used the roadway for some time, the amount of voids would be approximately 4 percent, as shown in Table II. This required a choked gradation of the coarser particle size of the fine aggregate and in a few instances the establishment of the upper specification limit for the intermediate material on the design curve. Close control of mixes at the plant, combined with careful inspection in the field, were the principal factors in maintaining uniform yet rapid production by the contractors.

After the job-mix formula had been established, all mixes were required to conform to it within the following ranges of tolerances:

Passing 3/8-in. and larger sieves	±5%
Passing Nos. 4 to 30 sieves, inclusive	±3%
Passing No. 100 sieve	±2%
Passing No. 200 sieve	±1.0%
Amount of asphalt cement added	±0.2%
Temperature of mix on delivery	±15 F

Basically, the procedure for mixing asphaltic concrete is to blend coarse aggregate, fine aggregate, filler and asphalt cement at a specified temperature to give a homogeneous mixture which will remain workable until it attains a normal temperature. Such a mix, of course, is designed to be placed on a firm base.

To obtain uniform production from asphalt batching plants, certain controls and check points along the assembly line must be maintained. Before production was started at any of the various plants, an over-all inspection of each plant was made with emphasis on the method of feed; the capacity of dryer, screens and aggregate bins; the automatic controls of the weigh box; and the pug mill. When these items were found satisfactory, the contractor was permitted to proceed.

Aggregates were inspected at the quarry for gradation and freedom from dust and foreign material before acceptance. At the mixing plants they were proportioned into the cold-feed elevator so that the flow through the hot bins would be uniform. Discharge of aggregate from the dryer at constant temperature was maintained by controlling the rate of feed into the cold-feed elevator.

Batch weights of the aggregates drawn from the bins—in most cases there were four bins—were controlled automatically. The hot aggregate was discharged into the pug mill and mixed for approximately 10 sec, then the asphalt was added, after which mixing continued for 45 sec to obtain a thoroughly blended asphaltic concrete. The mass was then discharged into a truck, its temperature checked, and the load covered for protection en route to the spreaders.

At each plant a field laboratory was operated by the section engineer to make complete tests of aggregates and hot mixes. These laboratories were equipped to run aggregate gradations, extractions, and the Marshall tests for stability, flow, and density. An independent commercial laboratory placed an inspector at each refinery from which asphalt was delivered to the job. These inspectors sampled and sealed each load so that approval was secured prior to use. In addition to these tests, cores were removed from the pavement and sent to the same commercial laboratory for a check test of the results previously obtained by the section engineers.

The plant inspection personnel generally consisted of three men familiar with mixing-plant controls and operations. The duties of one man were concerned principally with cold aggregate control; temperatures of aggregates, asphalt cement, and mixtures; and general plant operation. The other two men generally performed laboratory work consisting of frequent tests of gradations in the fine aggregate bin, gradations in the coarse aggregate bins, extraction and gradation of the mixes, asphalt penetrations, and Marshall stability, flow and density tests. Adequate and complete records were kept by the laboratory staff.

The following plants were used on the various sections:

Section 1.
2 Madsen batching plants, with 4,000-lb pug mills

TABLE II. AVERAGE CHARACTERISTICS OF ASPHALT MIXES

	Leveling Course	Surface Course
Mixing temperature	295 F	295 F
Stability by Marshall test	1,885	1,580
Density (theoretical max.)	2.55	2.50
Density (average field)	96%	92%
Flow by Marshall test	9	11

SECTION 2
- 1 S-80 Simplicity batching plant
- 1 S-100 Simplicity batching plant

SECTIONS 3 and 4
- 4 Madsen batching plants, with 4,000-lb pug mills

SECTION 5
- 1 Madsen batching plant, with 4,000-lb pug mill
- 1 Warren Brothers batching plant, with 3,000-lb pug mill
- 1 McCarter batching plant, with 5,000-lb pug mill

SECTION 6
- 1 Warren Brothers batching plant, with 3,500-lb pug mill
- 1 McCarter batching plant, with 4,000-lb pug mill
- 1 McCarter batching plant with 5,000-lb pug mill

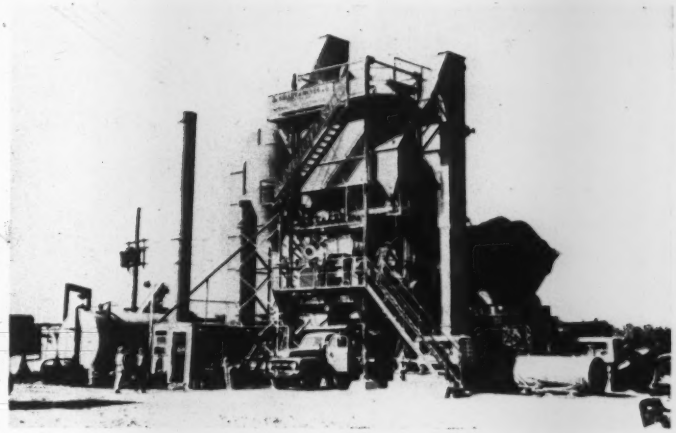
SECTION 7
- 2 Cummer batching plants, with 5,000-lb pug mills
- 1 Standard batching plant, with 5,000-lb pug mill

It was my responsibility to control the paving in such a way that a smooth non-skid riding surface with a uniform texture would result. The Turnpike Authority Specifications called for the three layers of asphaltic concrete paving to be laid over a penetration macadam base course $7^1/_2$ in. thick. This specification superseded the original one requiring the use of side forms and two courses of asphaltic concrete with a total thickness of $4^1/_2$ in.

The penetration macadam base course was required to be within $^1/_4$ in. of the specified profile grade as shown on the plans. In some instances deviations in the surface grades of the macadam course were found, and the low areas were corrected wherever possible with the approval of the section engineers, by constructing the first leveling course with an allowable compacted thickness of not less than $1^1/_2$ in. nor more than $2^3/_4$ in. The second leveling course and the surface course were laid in $1^1/_2$-in. layers (Fig. 1).

The minimum equipment used in rolling each asphaltic concrete course was one three-wheel roller of not less than 10 tons, one tandem roller of not less than 8 tons, and one three-axle bump roller of not less than 10 tons. If the tonnage of asphalt paving laid exceeded 125 tons per hour, but was not more than 175 tons per hour, an additional roller was required on the surface course only. Four rollers on the leveling courses and five on the surface course were used when the amount laid exceeded 175 tons per hour.

Initial rolling of the newly laid pavement was done immediately after paving to insure proper compaction and to maintain the desired densities and stabilities. Constant checks were made with either a bumpometer or a 16-ft straightedge, and a three axle bump roller was used to remove grade discrepancies.



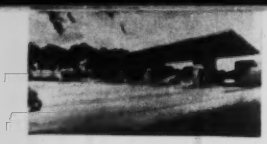
SIMPLICITY S-100 batching plant supplied asphaltic concrete for Section 2. A Simplicity S-80 plant also was used on this section.

To assure the same stability and density at the sides of the pavement, a stepped-up construction procedure on each layer of pavement was required. The penetration macadam base was constructed 18 in. wider than the desired asphalt concrete surface. The first leveling course was paved to a line 5 in. in from the outside edge on each side of the penetration macadam base, and the width of each succeeding layer of asphaltic concrete was decreased by 4 in., that is, 2 in. on each side. (See Fig. 1, below.)

A total of 17 Barber-Greene asphaltic concrete pavers and two

Fig. 1. Typical cross section shows method of stepping outer edges of three top courses of Turnpike pavement.

ALL MIXES were closely controlled at all times by field laboratories operated by section engineers at mixing plant sites.



Admix black-top pavers were used on this project, and mixes were supplied by 17 batching plants. Texture of mixes was maintained through a rigid plant control procedure. Paving inspectors in the field were well informed as to the texture desired and maintained constant visual inspection. Any variation in the paving mix was reported at once to the plant and corrections were made immediately.

At times it was very difficult to maintain the profile and template grade of the Turnpike because of the speed required in constructing the base courses.

It was the intent of the specifications to secure an asphaltic concrete surface course free from waves and irregularities to such an extent that the lower edge of a 16 ft straightedge laid on the surface parallel to the center line, would nowhere be further from the roadway surface than $\frac{1}{16}$ in. on the leveling courses, and $\frac{1}{8}$ in. on the surface course. In addition, the finished surface had to be within $\frac{1}{4}$ in., measured vertically, of the required grade and cross-section shown on the plans. In general, these tolerances were met throughout the entire Turnpike.

All paving contractors were required to construct an offset longitudinal hot joint at the center line of the roadway so that there would be no vertical center joint extending down through all three layers of paving. Experience has shown that this type of center joint will give additional strength and stability at this critical point, and will eliminate any possibility of a break extending down through the three courses of pavement if a plane of weakness should develop.

At 3,000-ft intervals on each 12-ft lane, the section engineers have had 4-in. cores removed from the finished pavement for testing to determine density, gradation of materials, asphalt content, and if possible, a stability and flow determination by the Marshall method. Out of every 10 cores removed, 6 will be retained and tested by the section engineers; 2 will be check tested by the commercial laboratory, and 2 will be kept for future use by the Turnpike Authority.

The testing laboratories utilized were Jersey Testing Laboratories, United States Testing Company, Gulick-Henderson Testing Company, and Newark Testing Company.

BIG EUCLIDS line up behind one of eight elevating graders used on Turnpike. Tremendous job of moving about 52 million cu yd of earth could not have been accomplished in such a short time without extensive use of heavy equipment.

Mechanized roadbuilding—the answer to tight

PRACTICALLY every noteworthy development in road building machinery during the past quarter century could be found working on the New Jersey Turnpike. Tremendous volumes of all items of work made possible maximum mechanization with consequent emphasis on skilled technical labor. The job provided a sharp contrast to road construction in the early part of the century, when mules, skinners and Fresno scrapers were the mainstays of the job. In carrying out nearly $200,000,000 worth of construction on the Turnpike, equipment and plant with a total value of $45,000,000 was used by the fifty different prime contractors.

There can be no greater monument to the ingenuity, toil and everlasting faith of the men of the construction equipment industry than this highway which has been built with their tools. Equally honored should be the men of the construction industry who manipulated the controls and guided those noisy, ground-jarring monsters so that they would produce a finished product conforming in every respect to the engineer's dream.

Total earthwork moved, including all classes of excavation and borrow, totalled 51,800,000 cu yd. To excavate this material it was necessary to utilize eight elevating graders each with a capacity of 1,000 cu yd per hour, twenty 2- to 3-cu yd power shovels, about 50 tractor-drawn or self-propelled pneumatic-type scrapers, and 25 draglines for mucking and ditching. To move and distribute this material, about 200 Euclid wagons varying in capacity from 15 to 30 cu yd and upwards of 500 trucks of various sizes were also employed, not to mention barges, dredges, and railroad trains.

For spreading purposes, bulldozers and power graders were used in the ratio of about 2 bulldozers to 1 power grader. Bulldozers were utilized generally for the preliminary leveling of large piles of material, and graders for the final spreading and shaping. Compaction of embankment was performed by multiple-unit sheepsfoot rollers and by pneumatic tire-type rollers. The sheepsfoot weighed not less than 3,000 lb per

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schedules and tough specifications

lin ft of drum and exerted not less than 500 psi per footprint, each footprint having a minimum area of not less than 7 sq in. The pneumatic rollers weighed not less than 2,500 lb per ft of width and had a load per tire of not less than 220 lb per in. of tire width. Conventional smooth-wheel rollers were permitted for auxiliary and final smoothing.

Thorough Foundation Preparation

The specifications provided for the preparation of foundation areas before any embankment was placed. They required the consolidation of the top 12 in. of the underlying subsoil to 90 percent of maximum density after all clearing, grubbing and topsoil removal operations were completed. In many cases, however, because of the generally unfavorable weather, unusual perched water-table conditions, and the necessity of completing the work within the specified time, it became necessary to place a layer of porous fill at the bottom of embankments and to obtain consolidation by using supercompactors weighing 50 tons or more so that work

VARIETY of equipment used is demonstrated in photo at right, where three scrapers, grader, sheepsfoot roller, and wobble-wheel compactor are all operating in small area.

QUANTITY of mechanized equipment is typified by this photo showing four trucks dumping and spreading lower course of macadam stone as three-wheeled roller follows close on heels of spreader.

AMONG less common types of equipment used on Turnpike were wobble-wheel compactor (below, right), shown compacting gravel subbase, and 50-ton supercompactor (below, left) shown pretesting macadam base courses. Materials placed in 6-in. layers were found to provide much more uniform surfaces than deeper layers even when supercompactors were used to consolidate the greater depth.

could proceed on the top layers without delay. In shallow, swampy and mucky areas, all unsuitable and unstable materials were removed by dragline or by dredging, and the areas were backfilled with porous material to a minimum elevation of 1 ft above tidewater or groundwater level.

Control of required density in the embankment material was a most important factor. Field density tests, representative of every 1,000 cu yd, were made in the bottom of all embankment areas. As the embankment work progressed these tests were reduced in frequency to a maximum of 1 per 3,000 cu yd, provided that the moisture content remained satisfactory and the density tests were reasonably uniform.

Two factors in obtaining the required densities are worthy of mention, as they had an important bearing on the maintenance of a rapid and uniform rate of progress. The first is that spreading should be done by a method that will give more or less uniformity in density in the loose material before any compacting operation is begun. It was rather convincingly established during the progress of the Turnpike work that bulldozer equipment did not give this desired uniformity but that power graders did. Where bulldozers alone were used, it was found that very uneven surfaces resulted and that considerable effort was required to correct this condition. Secondly, it was noted that materials placed in 6-in. layers throughout provided much more uniform surfaces than those placed in deeper layers, even when supercompactors were used to consolidate the greater depth.

Pavement Laying All Mechanized

The basic design adopted for the pavement included a select subbase, a penetration macadam base, a bituminous concrete surface, and stabilized shoulders. For the subbase, clean bank-run gravels were acceptable provided they contained a minimum of 75 percent of particles larger than $^3/_4$ in. Where clean gravels were deficient in coarse material, an armor plate of coarse gravel or crushed stone was permitted to insure stability. Limestone screenings were accepted for the subbase in areas where fills were made of very permeable, hydraulically placed sand. These screenings derived their stability from a cementing action between the particles and were very efficient in sealing off the top of the loose sand, thereby preventing the mixing of the sand fill with the subbase materials.

Subbase material was generally trucked to the job site and end-dumped in previously boxed-out sections of fill. Spreader boxes front-mounted on large bulldozers were occasionally used but spreading was generally done by motor graders. Layers had a maximum thickness of 6 in. and were compacted by pneumatic-tired wobble-wheel rollers or flat-wheel rollers. Surfaces were graded to within $^1/_4$ in. of the template grade.

Stone for macadam base courses was spread by spreader boxes front-mounted on large bulldozers or by Adnun stone spreaders. The latter machines were normally used on top course since they gave better conformation to grade. Initial compaction was performed by flat-wheel rollers and, in a few instances, by vibro-tampers. Asphalt penetration was accomplished by standard distributors, which were job supplied by tank trucks hauling directly from New Jersey and Pennsylvania refineries.

Various methods of final rolling were used for the macadam base. One contractor rolled freshly penetrated macadam by wetting the rolls of a bump roller, thereby preventing the asphalt from sticking to the rolls. Other contractors preferred to spread choke stone prior to final rolling. All macadam required choke stone but the contractor who elected to roll the penetration macadam prior to choking contended that this method reduced the amount of choke stone required and gave better interlock on the macadam stone. This contractor's contention proved to be basic-

STONE for macadam base courses is rolled (left) by three-wheel tandem roller after spreading by spreader boxes mounted on large bulldozers or by Adnun stone spreaders.

TANK TRUCKS applies penetration asphalt on base stone. Trucks hauled asphalt directly from New Jersey and Pennsylvania refineries.

ally sound. Final rolling after application of choke stone was done by tandem or bump rollers, and the macadam was tested with 50-ton pneumatic-tire rollers and construction traffic.

Bituminous concrete was mixed in both portable and permanent plants, but all plants were of the batch type. One contractor invested nearly one million dollars in a portable plant of four mixing units, each with a capacity of 125 tons per hour. This plant established a record of 6,200 tons of hot-mix asphaltic concrete produced in a single day. In less than six months it produced nearly 400,000 tons of asphaltic concrete. This plant alone provided the surface course for 45 miles of Turnpike. Material was hauled a maximum of 35 miles by truck and was spread by crawler-mounted spreaders. Rollers used for compaction were three-wheel, tandem, and bump types. Final rolling was done after the surface tolerance was checked with a rolling straightedge. Depressions and humps outside the specified tolerances were marked for corrective rolling while the asphalt was still warm.

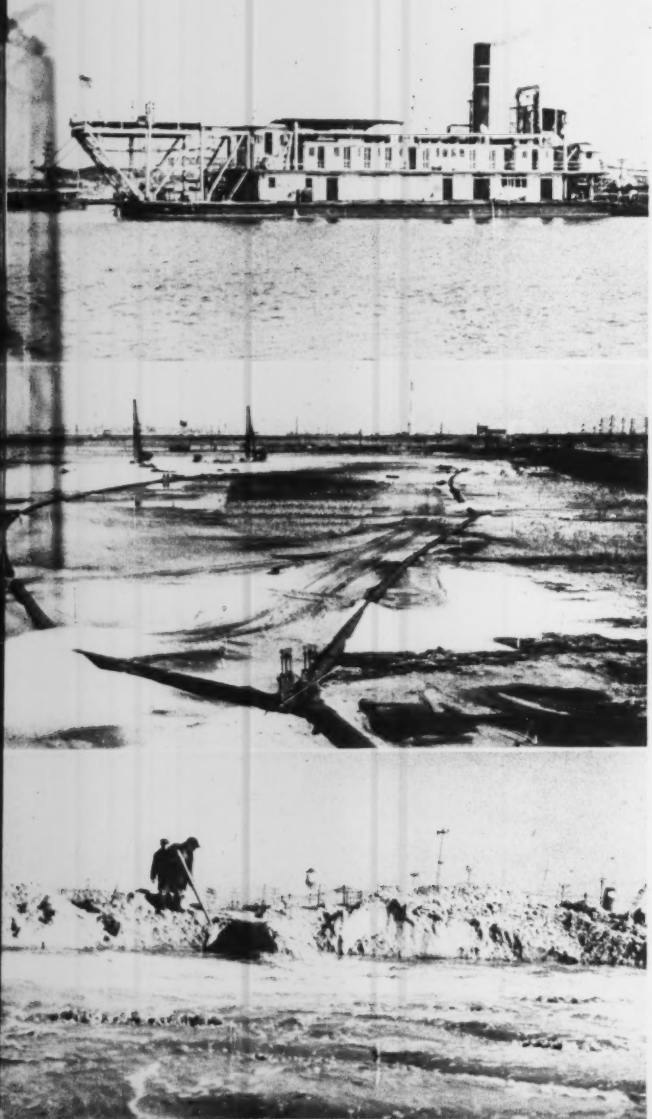
Shoulder materials were usually hauled to the job by truck and placed by a special spreading machine which operated on the finished pavement. Shoulder gravel or stone was dumped in the receiving hopper of the shoulder machine and was then transferred by belt conveyer to the shoulder area. Strike-off plates graded the shoulder material, extra material being left for subsequent compression under rolling. The shoulder machine is self propelled, mounted on rubber tires, and can spread shoulder material up to a width of 10 ft. Two applications of cut-back asphalt, on which stone chips were spread, penetrated and sealed the shoulder material.

Control surveys for paving were established by the engineer. Wooden stakes set to line and grade every 50 ft by the contractor were used for control of the subbase and the macadam base. Steel pins set to line and grade every 50 ft, also by the contractor, were used to control the bituminous concrete paving. Asphaltic materials were tested by consulting laboratories at the refineries, and all shipments were certified by that agency. Engineers provided plant inspection at quarries where macadam and surface-course stone were being produced.

Extensive on-the-job laboratories were also established by the section engineers for the design and control of mixes in the field. Tests included sieve analysis of materials for gradation, extraction of sampled mix, preparation and testing of samples for Marshall stability, and extraction of pavement cores, which were tested for density and stability. Further details of the tests are given in the article by Leslie M. Stewart; the

FIRST COURSE of bituminous concrete is placed on northbound lane at North Camden Interchange.

EXTENSIVE AREAS of sand embankment were filled hydraulically. Over 5,000,000 cu yd of sand was placed in this manner. The sand, which was dredged from lower New York harbor, was carried either by dredge (such as *R. A. Bunkman* shown below) or by barge. Hydraulic fill was eventually pumped through permanent boat lines at dockside (below, center) and deposited in 3- to 4-ft layers (bottom photo). Runoff was controlled by wood spillways. Excellent compaction was achieved.



Special Bituminous Consultant retained for coordination and over-all supervision of paving operations.

Structures Erected by Conventional Methods

In the structural work there was little deviation from conventional methods, particularly in so far as equipment was concerned. The most distinguishing feature was the vast amount of equipment that had to be assembled for construction of the more than 260 structures in the project. Some unexpected difficulty was encountered in driving cast-in-place pile shells through embankment areas where densities in excess of 90 percent of the theroretical maximum had been obtained. Driving of pile shells through material as dense as this is unusual. However, it was considered advisable to drive these piles well into the underlying subsoil to minimize structure settlement due to subsidence in the subsoil.

In many instances, the desired penetration could not be obtained with reasonable driving effort. In those instances, it was assumed that sufficient subsidence had already taken place in the subsoil as a result of the weight of the overlying fill, and that no appreciable further settlement could be expected. Where difficulty was encountered in getting through the overlying embankment, jetting was resorted to or permission was granted to augur-bore holes in the fill for a depth not to exceed one-half the depth of the embankment.

Many steel bearing piles were used, the maximum length being 110 ft. In numerous instances, an unusual number of battered piles were required. This requirement complicated and slowed down the contractor's operations although it did not call for any unusual equipment or methods. At the Hackensack River, the cutoffs were at El. −50, an arrangement that required an unusual depth of open cofferdam for pier construction. At the Passaic River crossing, some difficulty was encountered in the open cofferdams for the river piers because of the seamy nature of the underlying rock. Unexpected flooding of these cofferdams, which occurred during the progress of the work, could have been avoided by constructing a double-walled cofferdam initially. The preliminary borings, however, did not indicate the seaminess of the rock bottom, and flooding could not have been reasonably anticipated. Mud packing and extra-hard driving on cofferdam sheeting ultimately sealed off the leaks and permitted the pier base to be poured in the dry.

In another article, Mr. Paul explains the erection methods used on these two important bridges over the Hackensack and Passaic Rivers.

Despite the similarity of deck features and arrangement on these bridges, separate deck contractors chose entirely different methods of surface finishing. In one instance a full 36-ft-wide power-driven finishing machine was used. In the other case, longitudinal screed rails were erected, and finishing was accomplished by 12-ft vibrating screeds.

Sand Drains Require Pile-Driving Equipment

The placing of sand drains was unusual in that exceptionally long leads were required to hold the hollow steel mandrels which were driven to contain the sand forming the vertical sand columns. The leads themselves were more or less conventional fixed leads except for their unusual height and an attached elevator-type hopper for pouring the sand into the mandrel. Each sand-drain rig was a mobile self-contained unit. The size of the hammers used varied with the diameter of the mandrels and the type of resistance encountered. The heaviest hammer used was a McKiernan-Terry S-5. Single-acting hammers were found to be the most economical. They retarded crystallization of the metal in the mandrels from constant use.

Driving of sand drains was a nearly continuous operation because of their close spacing (from 4 to 12 ft). Extensive moves of the rigs were the exception. Control and supervision of the driving was the same as for any normal pile-driving operation except that this was faster and required careful checking of depths, since there was no specified cutoff or predetermined depth of bottom which could be used as a check. Once the mandrel was withdrawn from the ground and the sand column left in the hole, there was no reasonable method for checking the depth unless a very careful measurement was made of the volume of the sand placed in the mandrel. Such a check was difficult since the mandrel usually was slightly overfilled to insure a sand column of full height.

The operation of placing sand drains is relatively simple. The mandrel, with its hinged bottom gate, which is 2 in. greater in diameter than the mandrel itself, is driven in the same way as any driven pile. It is not necessarily driven to refusal or to any predetermined depth, but to firm bottom or to within a reasonable distance of firm bottom as previously determined from borings. When the mandrel approaches firm bottom, sand is introduced into the top of it from the elevator hopper, which is raised on the outside of the leads. The mandrel should be loaded with sand before the driving is discontinued in order to eliminate the tendency of the sand to bulk inside the mandrel.

After the required volume of sand has been placed in the mandrel, the mandrel is sealed off at the top. Air or steam pressure is then applied at the top of the sand to hold it in position while the mandrel is slowly withdrawn. When pulling of the mandrel begins, the hinged gate at the bottom of the mandrel opens. As the mandrel is withdrawn the sand remains stationary except that it expands somewhat to fill the entire hole. In another article Messrs. Porter and Urquhart explain the function of sand drains in consolidating the marsh areas.

Ocean Sand Placed in Hydraulic Fills

An operation of unusual interest and novel conception was the placing of ocean sand as fill by the hydraulic method on the section of Turnpike from Elizabeth through the Newark Airport area to Raymond Boulevard in Newark. This method is now being used also to construct the new runways of extraordinary length for the Newark Airport adjacent to the Turnpike. Over 5,000,000 cu yd of this material was placed for the Turnpike. Of this, 750,000 cu yd was placed in the peak month.

Two basic methods were used to handle the sand from the water-side booster station. The first consisted of loading hopper dredges in lower New York Bay and discharging the

TYPICAL of lighter pieces of equipment used throughout Turnpike are two rigs shown below. Choke stone, in upper photo, is being drag-broomed south of Mountain Laurel Road. Drainage ditch, in lower photo, is being machine graded by Warner-Swasey Gradall.

loads, varying from 2,000 to 3,000 cu yd per dredge for the three dredges in use, at boat lines permanently set at dockside in the extreme westerly end of Port Newark Basin. The dredge pumps moved the material through spiral welded pipelines to a booster station where electric-motor-driven pumps propelled it up to 2½ miles further.

The water-borne sand was deposited first on firm ground or on an area in which sand drains had been driven to stabilize the soft underlying material. After the first layer of sand was placed, bulldozers built sand dikes to retain the rest of the fill. Wood spillways were constructed to control the runoff water and carry it to the marsh. Succeeding layers, deposited to depths averaging 3 to 4 ft, eventually built the fill up to grade. Dredge water seeped out through the porous fill, and excellent consolidation resulted.

The second method of handling the sand to the booster station consisted of loading bottom-dump barges by dipper dredge in the vicinity of Long Island. The barges were towed to the same location in the Port Newark basin mentioned above, where they dumped their loads on the bottom. A reconditioned hydraulic river dredge was then placed in operation in the basin to pick up the sand from the bottom as it was deposited and pump it to the booster station. Beyond that point, the operation was the same as that previously described.

Mobile Radio Communication Expedited Operations

Mobile radio communication played a prominent role in controlling construction along the 118-mile length of the project. A minimum of six frequencies with 20 base stations and over 100 mobile stations were authorized and in use by the various contractors. The service rendered by these stations was invaluable in saving precious time on this accelerated project. Coordination of service and repair crews under the control of mobile radio was excellent, and operation planning on split second schedules was greatly facilitated. A typical example of the kind of coordination made possible by the mobile radio was the occasion when an asphalt paving spreader completed operations at one location and resumed operations at a second location 8 miles distant in 20 minutes. Coordination of material trucks, plant operation, and transfer truck-trailers were all radio controlled with a minimum loss in plant operation.

One contractor, George M. Brewster & Son, used a series of base stations, from Bogota in northern New Jersey to Woodbine in southern New Jersey, for the control of operations involving 13 contracts totaling approximately 40 million dollars. Another contractor, the Bethlehem Steel Company, used handy-talkies for controlling the erection of major steel girder sections weighing up to 172 tons on the Passaic River Bridge.

Miscellaneous Mechanized Contracts

Contracts for dress-up items such as the center stripe, guard-rail, delineators, traffic signs, and electrical lighting were awarded for the entire Turnpike or in major divisions to obtain the maximum possible uniformity. The center stripe was placed in 25-ft dashes with 25-ft skips by spray machines traveling under their own power and automatically starting and stopping the stripe painting to provide the dashed lines. Glass beads were dropped in the paint as it was applied to give a reflective quality for night travel.

Power augurs were used to excavate the post holes for the guardrail and for traffic signs. Beam-type guardrail was erected rapidly using electric impact wrenches operated by small generators carried on trucks. Guardrail and posts were given an initial coat of paint in storage yards to accelerate operations and effect economies. All traffic signs have reflective letters and symbols or are electrically illuminated.

Delineator posts and right-of-way fence posts were driven with a novel self-powered rubber-tired rig having a fixed tubular boom from which was suspended an air-operated jack-hammer mounted on a beam that could be raised or lowered to suit the driving height of the post. This machine drove delineator posts as it moved along on the outside improved shoulder, using a template guide to mark the post location with reference to the edge of the pavement.

Jeep trenchers were used extensively to install underground electric lighting conduit. Light-standard bases and concrete junction boxes were precast and set by truck cranes. Toll houses were completely prefabricated and installed as a unit.

A Typical Contractor's Equipment Inventory

The Savin Construction Corporation of Hartford, Conn., held contracts for all grading and paving and part of the structures on one 18.7-mile section of the Turnpike in the vicinity of Camden, N. J. The following list of equipment actually used by this contractor is presented as typical of the construction equipment employed on the Turnpike:

7 passenger automobiles
15 pickup trucks
2 tractor - trailer trucks (low bed)
2 tanker trailers
1 pole trailer
2 welding trucks
3 platform trucks
29 dump trucks (3-axle)
2 grease trucks
1 fuel truck
24 tractors, heavy
2 tractors, light and farm
1 Tournadozer
4 shovels, 2- to 3-cu yd
2 backhoes
3 truck cranes
5 crawler cranes
2 Euclid elevating loaders
1 Hauss loader
15 bottom-dump Euclids, 12-cu yd
9 bottom-dump Euclids, 25-cu yd
2 Euclid rear-dump trucks
3 Heiliners, 12-cu yd
3 Stump wagons
2 Euclid Pioneer scrapers
10 tractor - drawn scrapers, 15- to 24-cu yd
7 graders
6 compressors, 60- to 500-cfm
4 sheepsfoot rollers (2 drum)
4 wobble-wheel rollers
4 tandem rollers
6 bump rollers
2 three-wheel rollers
1 Bros 50-ton super-compactor
1 rooter
3 Adnum stone spreaders
1 Jaeger stone spreader
2 Buckeye chip spreaders
1 Barber-Greene bituminous pavers
2 Blaw-Knox buns
1 Syntron electric feeder
1 Barber-Greene stationary conveyor
1 Robbins car shakeout
1 S-80 Simplicity asphalt plant
1 S-100 Simplicity asphalt plant
3 pile hammers
1 pile extractor
2 sets pile driving leads
14 buckets (dragline, clam-shell, concrete rehandling)
2 steam jennies
4 welding machines
1 disk harrow
2 portable light plants
1 power screed for concrete bridge decks
4 electric saws
2 portable generators
1 Barco rammer
3 chain saws (1 air, 1 electric, 1 gasoline)
1 electric sander
1 paving breaker
1 jackhammer
3 concrete vibrators
6 gasoline pumps
1 power hack saw
6 Motorola mobile receivers and transmitters
1 Motorola base station

There were also many small power tools and other items too numerous to mention.

The intense and successful mechanization of construction on the New Jersey Turnpike should create a pattern for future projects of major size where completion is required on expedited schedules. No operation was perfect, however. Every process is subject to refinement. Particularly needed is an asphalt paving machine with electronically activated screeds which will transfer a grade line from a wire or light rail section set to true profile to give a perfect riding surface. Placement of granular materials by hydraulic methods gave excellent compaction with minimum effort. There is the possibility of adapting this method to smaller inland jobs. Other improvements are being studied and are looked for with considerable interest. It is certain that still greater mechanization will characterize future progress in road-building techniques on large-scale projects.

A contractor selects his equipment and methods

W. W. BLAUVELT, Vice-President and Chief Engineer, George M. Brewster & Son, Inc., Bogota, N.J.

THE New Jersey Turnpike is rightfully named the Miracle Turnpike, as its 118-mile length, through highly industrialized areas in the northern part of the state and residential and agricultural areas in the central and southern parts of the state, will have been constructed in less than two years.

Our company was involved in both grading and paving on Section 7 (8.6 miles), Section 4 (24.5 miles), and Section 3 (21.7 miles). Grading on the northern section, consisting mostly of embankments through the marsh and tidal flats, where we constructed 2,781,500 lin ft of vertical sand drains to obtain settlement, presented a different problem from that found on the central and southern sections.

In the north, the furnishing of embankment material required over-the-road trucks for the movement of the various types of embankment — sand-blanket material from docks, and various types of selected subgrade material from upland borrow pits.

In the central and southern sections, our problems consisted of moving excavation and constructing embankments with over-the-Turnpike equipment. This equipment consisted of dual-engine Euclid scrapers, Euclid conveyor loaders, Euclid bottom-dump trucks, 2½-cu yd Bucyrus-Erie power shovels, 50- and 100-ton compactors, and some over-the-road trucks where it was necessary to transport borrow for embankments. Thus it is seen that the contractors who had northern as well as southern sections had to employ different types of equipment on the different sections to accomplish construction as planned and specified.

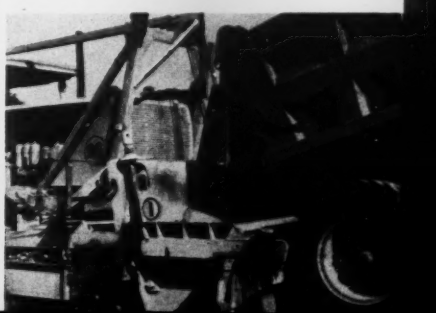
While the grading of the Turnpike presented many problems, it resolved itself chiefly into the selection of the proper equipment to perform the work on each section. When this problem had been satisfactorily solved, the movement of 13,543,240 cu yd of earth was accomplished on our contracts in a very short time. This total was made up of 4,548,040 cu yd of excavation, 7,739,000 of borrow, and 1,256,200 of miscellaneous excavation for bridge abutments, channel correction, and muck removal.

As regards the paving work, the contractors' major problem was to obtain the materials. On our Sections 3, 4, and 7, the quantities of subbase material, crushed stone, asphalt cement, and bituminous concrete were enormous and unparalleled considering the shortness of the construction period. However, after careful planning and consideration, we decided to treat our northern section, requiring 275,000 sq yd, as one problem of material supply, and our central and southern sections, requiring 1,491,000 sq yd, as another separate problem of material supply.

For the northern section, 105,000 tons of crushed stone were required, and three upland stone quarries were selected as the sources of this material. The crushed stone had to be furnished at an average rate of 1,000 cu yd per day, and the peak daily demand ran as high as 5,000 tons. The crushed stone was delivered by dump trucks, of which as many as 65 were needed on peak days and as few as 15 on average days. The stone was spread by tractor-powered stone-box spreaders of our own design, which proved very efficient. After spreading, the stone was vibrated by vibro-tamper machines, then rolled with three-wheel rollers and bump rollers.

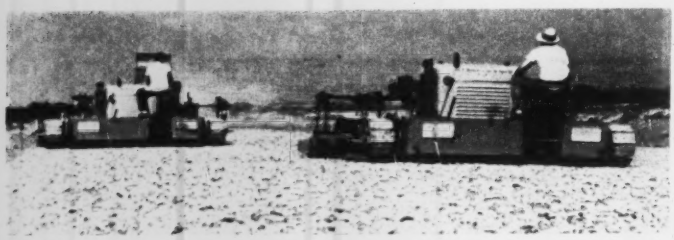
The 69,000 tons of bituminous concrete required on the northern section came alternately from three permanent asphalt plants. The average daily supply was 1,250 tons, and the peak-day supply, around 2,200 tons.

The 977,000 tons of crushed stone required on our central and southern sections was secured from several sources: from the North Jersey Quarries at Bound Brook, N.J., with 26- and 45-mile average hauls, respectively; from the Kingston Trap Rock Co. at Kingston, N.J., with a 16-mile average haul; from the New York Trap Rock Co., at South Amboy, N.J., with a 22-mile average haul; and from the John Dyer Co. at Birdsboro, Pa., with a railroad haul and an average truck haul of 6 miles. In all, 31,000,000 ton-miles were required to deliver this material



SPREADER BOX attached to Caterpillar tractor was designed by Geo. M. Brewster & Son, Inc. In near view subbase material is spread as truck dumps it into spreader box. In view at far right same method is used to spread lower-course penetration macadam.

TOP SOIL for center strip and parked areas is stripped off by Euclid conveyor loader. Similar equipment was operated in borrow pits.



PAIR of vibro-tampers compacts lower-course stone (upper view). For hauling stone Brewster operated a fleet of 300 dump trucks. In view below, upper-course stone base is penetrated with asphalt.

HERE first leveling course is being laid, with Barber-Greene spreaders, on top of penetration macadam and rolled. On Brewster's central and southern sections, fleet of 143 asphalt trucks hauled 389,000 tons from big plant at Cranbury, N. J.

from quarry to Turnpike roadbed, using 300 large over-the-road motor dump trucks.

To take advantage of crushing time while grading operations were still going on, crushed-stone stock piles were established at advantageous points along the Turnpike. Then, when the subgrade was ready, crushed stone could be delivered to the roadway as required, without interruption, as the stock piles were replenished on a 24-hour basis. Crushed stone was delivered to the stock piles at the rate of 6,000 cu yd per day on peak days, or an average of 4,000 tons per day.

The bituminous concrete for our central and southern sections was manufactured and supplied from an asphalt plant located on the Turnpike adjacent to Half Acre Road, Cranbury, N.J. The plant established by our company consisted of four Madsen 4,000-lb plants with conveyors and bins for the handling of the asphalt materials. We furnished the crushed rock to our subcontractors, McMinn's Industries, Inc., and Tioga Construction Co., Inc., who operated the plant, furnished the bituminous cement and sand, and hauled, spread and rolled the paving material. The total asphalt output was 389,000 tons, or an average of 77 tons per hour per plant. These four batching plants established a record production of 6,200 tons in a single day. The average haul to our southern section was 22½ miles, and to our central section, 6 miles. On this operation, 143 asphalt trucks hauled 5,320,—500 ton-miles.

When the asphalt arrived at the designated location on the Turnpike, it was dumped into a Barber-Greene asphalt spreader and spread on the roadbed in three 1½-in. layers and then rolled with tandem and bump rollers. The spreader production was 71 tons per hour per spreader. Two spreader and roller units were used in tandem, one on each half of the roadway, so that a completely hot joint along the center line was obtained.

During 1950 and 1951, the New Jersey Turnpike Authority awarded our company 13 prime contracts and three subcontracts, totaling $42,000,000. Our work was practically completed by the end of 1951, only a small part of our northern section remaining to be completed in the early part of 1952. Never before in its history has our company been called upon to perform such enormous quantities of work and to supply such great quantities of materials as have been required by its contracts with the Turnpike Authority.

TYPICAL SERVICE FACILITY provides lunchroom, roadside auto and truck service, ample parking area, and modest picnic grounds. Facilities were designed to encourage travelers to stop and rest.

Service facilities designed for maximum public convenience

ROLAND A. WANK, FAIA

Fellheimer and Wagner,

Architects and Engineers, New York, N.Y

SERVICE FACILITIES on the Turnpike comprise an administration building, 6 maintenance headquarters, 20 toll stations for the 17 interchanges, 6 equipment stations for the short-wave communication towers, and a chain of concession buildings.

General design criteria were established by the members of the New Jersey Turnpike Authority. All buildings for the same purpose were to be uniform for efficiency of procurement, construction, and operation. All structures and all features of their sites were to be planned for expansion either by enlargement or by additions to particular features when they became necessary to meet the demands of traffic. Other requirements were that the buildings be attractive and helpful in the conduct of favorable public relations, that they be substantial to minimize maintenance, and that they be fire-safe in view of their more or less remote locations. They were to be as economical as possible, consistent with the foregoing objectives.

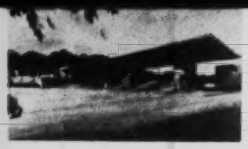
With respect to geographic distribution, the service facilities tend to be much more closely spaced north of the Raritan River because of heavier traffic, more severe weather conditions, and special maintenance on long viaducts and bridges near the north end of the Turnpike.

Choosing Site for Administration Building

These same factors influenced the Authority to seek a site for the Administration Building near the northern third point of the Turnpike. This put it close to the center of operating and maintenance activities. Other considerations governing the choice of this site were that it should: (1) command a view of a long stretch of Turnpike; (2) be convenient to Trenton as well as to the metropolitan area; (3) be easily reached by private car from each direction by way of the Turnpike; (4) be at or near an interchange; (5) be well located as regards a railroad, that is, near an express stop of the Pennsylvania Railroad; and (6) be convenient for employees, that is, within walking or bus commuting distance of residential areas. Further, attention was given to the availability of urban services and public utilities.

The site was to be attractive as to scenery and neighborhood, and ample to accommodate an unpredictable amount of future building expansion, in addition to providing separate parking areas for official cars, employees and visitors. Finally, since any excess land acquisition was unpopular with the public, preference was to be given to parcels acquired in lieu of compensation for severance or other damages.

Four alternative locations were analyzed, leading to the choice of the



loop at the New Brunswick Interchange, that is, the triangular plot between the Turnpike, the toll plaza, and Route S 28.

The plan made the most of the hilltop location. The principal offices overlook miles of Turnpike, the Raritan River Bridge, and the toll plaza with its ramps.

Sites for maintenance compounds were selected near the mid-points of the six maintenance divisions (Fig. 1). A study was made of the possibility of combining these six structures into larger ones, situated at division points to serve in both directions, but the increased operating costs and the handicap on prompt action in snowstorms or at other critical times made this arrangement inadvisable.

Selection of sites for maintenance compounds began also by examining parcels which had been bought in lieu of severance damages, in the light of the following criteria:

1. Availability of a minimum of 5 acres (in the case of the central unit, 12 acres) of area, suited by topography and soil conditions to outdoor storage and vehicle parking.
2. Direct access to the Turnpike, with long sight distances, at the point of access.
3. Road access for employees and deliveries and for the extension of utilities at reasonable cost.
4. Availability of labor and of repair facilities nearby.

Application of these principles led to the selection of five sites from among the parcels already owned by the Authority. The sixth site had to be specially acquired.

The best manner of access from maintenance compounds to the Turnpike was studied. Since the experience of other high-speed highways showed no record of accidents attributable to the direct type of access, such access was judged adequate except for the two northernmost maintenance divisions. These will serve stretches of very high traffic density, where tie-ups resulting from snow or other emergencies could bottle up the maintenance equipment sent to correct the situation. Therefore, those sites were so selected that equipment stationed there will have several choices of entrance points to either side of the Turnpike by making use of adjacent concession areas, overpasses, and toll plazas.

Special arrangements were also made for the headquarters of Maintenance Division No. 3, which was selected for development into a center for repair shops, general warehousing, and storage. It is well situated for that purpose, between the approximate center of gravity of operations and the geographic middle of the Turnpike, near the Borough of Hightstown on which it will depend for employees and services, and near enough to the Administration Building for close supervision.

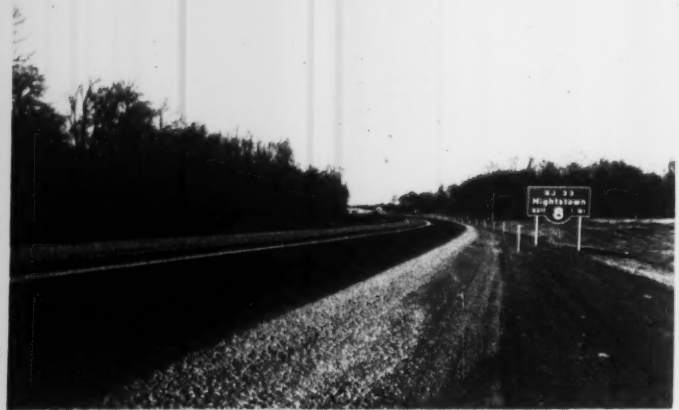
Like the Administration Building, the central maintenance compound was placed within an interchange loop where the land had already been bought for other reasons. The area within the loop was used also as a borrow pit; consequently, grading of the site was obtained as a by-product through advance planning of the excavation.

Maintenance buildings were designed to follow a uniform plan. The offices are oriented to control the Turnpike access, and the main body of the building is divided into two parallel bays—one for miscellaneous facilities, shops and stockrooms, and the other for automotive maintenance. The other five maintenance buildings will be much shorter, but at all six, any one of the component floor spaces—offices, shops, or maintenance space—can be enlarged, alone or together, as may be needed.

The buildings are not large enough to store more than a fraction of the maintenance vehicles and equipment. Provision was made on the site plans for storage sheds, but the rise in construction costs made it necessary to postpone their construction. Quonset huts will be used for the storage of salt and other bulky items.

For policing purposes, the Turnpike has been divided into three divisions. The simple office facilities needed for police division headquarters are incorporated in other structures—one is in a maintenance building, one in the utility building of an interchange, and the central headquarters is part of the Administration Building. The requirements for equipment rooms of the short-wave communication system were less flexible, and it was found necessary to erect four minor structures to house that equipment.

HIGHWAY SIGNS were designed to be easily read at high speeds. They are placed so as to give motorists ample warning of approaching exits.



Design of Toll Collection Facilities

At the toll stations it was originally intended to have single booths serving single traffic lanes so that all transactions would take place at the left hand of the driver, but cost considerations favored the use of double lanes; so all booths have been made double, arranged in tandem.

After various methods for constructing the toll booths had been considered, a prefabricated, welded steel plate construction was decided on. This type offers the greatest protection against accidental injury to collectors, and it was possible to award this type of booth to the same manufacturer who had the contract for the treadles and collection equipment.

Random ashlar stone facing will protect the base of the steel booths from mud splash and exhaust gases.

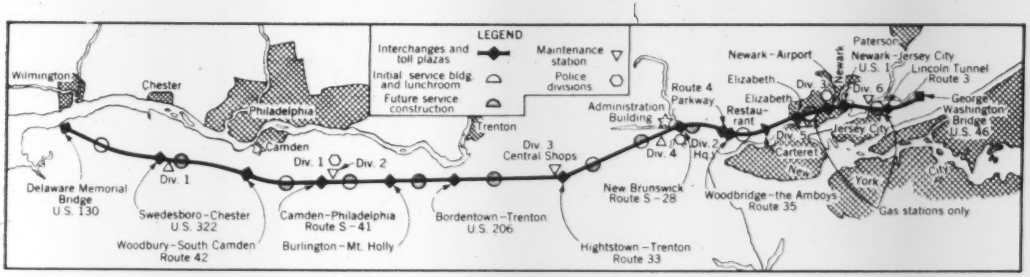


FIG. - 1. Administration building, marked by star on map above, is located at one of 17 interchanges along Turnpike's 118-mile length. Site near northern third point of Turnpike was chosen because of nearness to center of operating and maintenance activities. Photo at lower right shows building under construction.

Diagonal corrugated aluminuin sheathing will cover the space for heating equipment above the booth ceilings, and the cantilevered canopy will slope, like a shed, in one direction. The Turnpike sign will be protected and illuminated under the high side, which is turned toward the entering cars, while the low edge of the roof will hide the reverse view of the sign and the lights from approaching cars.

The utility buildings at toll-collection points were designed to the narrowest practicable width (15 ft) and were correspondingly elongated, to conserve expensive grading. Employee facilities were laid out for possible division between the sexes should the Authority want to employ women as daytime toll collectors. A special entrance was provided at the Turnpike ends of utility buildings for the exclusive use of the tellers. They are the only persons in possession of keys to these ends of the buildings, in which the treadle recorders and the vaults for cash and tickets are located. The tellers do not pass through the toll stations in the course of their collection trips. At the several one-way toll stations, special provisions have been made to route the tellers' cars in conformity with this principle.

Policies Governing Concessions

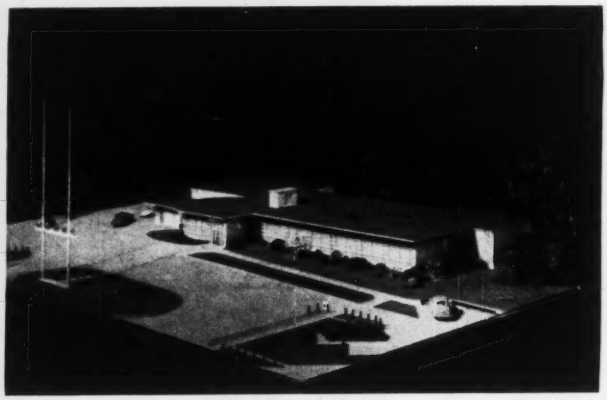
Planning of concession facilities was based on the following considerations:

1. The traveling public is entitled to proper service and comfort on a toll highway.

2. Attractive facilities will be justified by the substantial portion of the total income which will come from the concessions.

Next came the question of ownership of facilities. To depend on the concessionaires to erect their own buildings, as on the Pennsylvania and Maine Turnpikes, would have reduced the initial capital investment by the Authority. But it seemed clear that greater revenue would be obtained by direct ownership by the Turnpike Authority, and the financing could be done more cheaply by the Authority than by any concessionaire. Unusually favorable ar-

PREFABRICATED, WELDED steel plate construction was chosen for toll booths. Each booth serves two traffic lanes.



MODEL shows typical lunchroom, lounge and gift shop. Facilities such as these are so designed that they may be easily expanded as need arises.

rangements were made with the concessionaires, thus justifying the decision of the Authority to own and construct its own buildings.

It was agreed that concession areas ("half sites," a word coined for the purpose) were to be paired on opposite sides of the road. A distance of 10 to 12 miles between concessions was chosen as sufficiently convenient for the traveler. This spacing resulted in a total of 23 half sites for the 118 mile length of the Turnpike, the odd number being due to a special condition related to shore resort traffic.

Approximate locations were then spotted on a map as a basis for selecting actual sites, which were chosen and rated by the following standards:

1. Sites should be on high ground for better visibility and views, and also to aid in the deceleration of vehicles turning into the concession and the acceleration of those returning to the Turnpike.
2. Ample sight distance should be available. Therefore concessions should not be placed just past a crest of the road or directly behind an overpass.
3. Space should be available for full length (1,200 ft) deceleration and acceleration lanes.
4. Sites should be remote from interchanges to avoid excessive weaving of traffic caused by the two facilities.

Other considerations included accessibility from public highways, topographic and subsoil conditions, provision of utilities, scenic quality, and cost of land.

The Authority decided to acquire all the land needed for the predicted requirements of the first 25 years. Near the north end, suitable parcels were almost impossible to locate, and in this section some second rate locations, involving high costs for stabilization of ground, for water supply, and for sewage disposal, had to be used for lack of better ones.

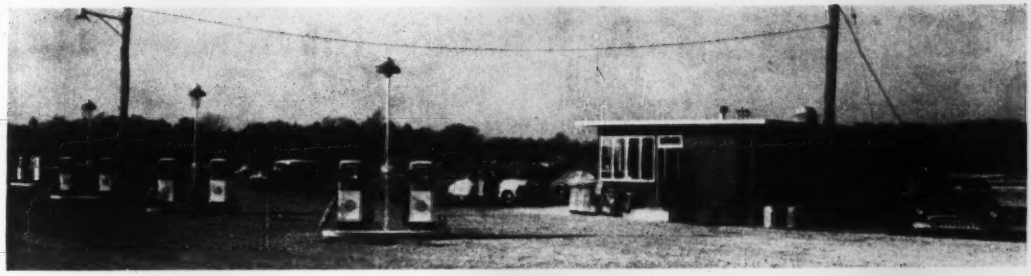
Assumptions relating to eating facilities were made after observation of comparable enterprises and consultation with prospective lessees. It was determined that lunchrooms with counters and booths are desirable at all locations where travelers stop for motor fuel but that full-fledged lunchroom-restaurant combinations are required only at a few locations. Initial construction of restaurants was reduced to "one twin site near Woodbridge. This site was chosen because it is the furthest point from the metropolitan area that will still serve traffic to and from shore resorts using Route 35.

Experience on other enterprises indicated that for best service to patrons and efficiency of operation, the seating capacity of roadside restaurants should not exceed 350. The Turnpike restaurants were designed for an initial capacity of 200 with expansion to 350, and provision for future enlargement. Lunchrooms were designed to seat 65 persons, with provision for the addition of units which may take the shape of either lunchrooms or restaurant dining rooms, as may be indicated by experience (Fig. 2).

It is planned to construct a future twin restaurant group, comparable to the one at Woodbridge, near the junction with the direct Pennsylvania Turnpike connection when that facility is built. Another such group is under construction near the Camden-Philadelphia region for traffic to and from that area, but, on account of cost limitations, this will be equipped initially as a lunchroom only.

A thorough analytic investigation was made of automotive service requirements. Some of the principles adopted for service stations follow:

1. All stations are to dispense two grades of gasoline at all islands, and diesel fuel also, at islands set aside for trucks. This requirement resulted in adoption at each station of four-pump islands (two sets of paired pumps for each island), 50 ft long for passenger cars, and 120 ft long for trucks, to accommodate trailers. As the islands assigned to trucks are furthest from the concession buildings, few of them will be built initially. Until they are ready, trucks will use the last passenger-car island.



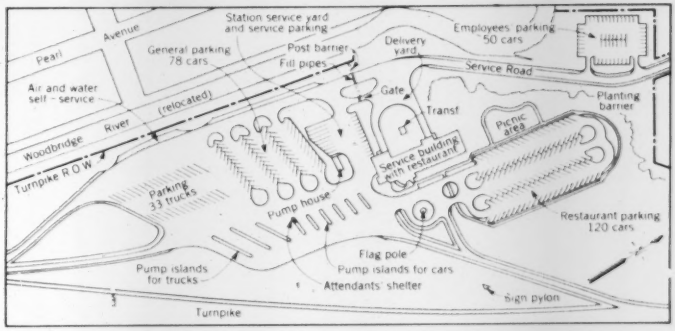


FIG. 2. CONCESSION SITES are remote from interchanges to avoid excessive weaving of traffic caused by two facilities. Full-length, 1,200-ft acceleration and deceleration lanes are provided at all service sites.

2. Connections from the vending pumps to the fuel storage tanks should permit switching from one fuel to another as demand warrants.

3. Lubricating oil is to be sold at the islands. Water and compressed air will also be available there, but during peak periods patrons will be asked to move to the service yard for air and water, or to self-service stations placed on the exit roads of the concession.

4. The stations are to be equipped to make oil, tire and battery changes and minor repairs.

5. It was thought unlikely that the larger trucks would need any supplies or mechanical assistance save on exceptional occasions. Nevertheless, the services are planned so that truckers will find them adequate.

6. Facilities for oil changes, wash and grease jobs should be more ample where a lunchroom-restaurant is provided than at the lesser concessions. A single lubricating bay is to be provided for lunchroom-type concessions, with space for additional bays.

Some of the other general considerations pertaining to concession site development may be of interest. Since stopping along the Turnpike is prohibited as a traffic hazard, it was agreed that some provision should be made for travelers who bring their own lunches or who wish to stop and rest without patronizing the restaurants and lunchrooms. Accordingly modest picnic grounds have been provided.

Bus companies were consulted as to whether they intended to use any of the concession areas as rest stops. Their answers being negative, no facilities of any kind are contemplated in connection with potential bus traffic. Buses will have to leave the Turnpike before they can take on or discharge passengers.

Telephone booths are to be provided at all concession buildings as numerous calls are likely to be placed by drivers approaching the metropolitan area to reserve accommodations, to obtain truck berthing and delivery instructions, or to send word of delays.

There is space for vending machines in concession buildings and also for small souvenir shops. It is expected that the sale of travel necessities also will be profitable.

Pay toilets with washbasins will be provided in addition to the free washroom facilities. Concession buildings contain good-sized lounges, which, since they are centrally located, are being built to their ultimate size. All other spaces are so arranged in wings that any one element can be expanded independently, or the building can be expanded as a whole.

Space requirements for motor-fuel sales were developed on the assumption that one gallon of fuel would be sold on the Turnpike for every 20 miles driven on it. This principle was applied to each stretch of road to be served by a given concession site. Two assumptions were then made: (1) that gas sales would be proportionate to the number of vehicle-miles driven on that stretch; and (2) that they would be proportionate to the traffic density on the stretch. The arithmetic mean of the two propositions, adjusted for proximity to state lines or other special circumstances, yielded the gallonage prediction for each site for the selected years—1952, 1956, and 1975.

It was then decided to proportion the number of pumps so as to avoid waiting during the peak hour, and experience figures were used regarding the number of gallons sold in each transaction and the time required for each sale. The result determined the number of pumps for each site for each of the three selected years. To determine the number of parking spaces and toilet fixtures, the requirements for motor-fuel customers and those for restaurant or lunchroom patrons were added together. All figures came out substantially higher than expected. However, the figures were checked and were further confirmed by independent estimates of bidders for concession leases.

Paying for new sewage

SALIENT features of a panel discussion on financing sewage treatment plants conducted by the Sanitary Engineering Division during the recent ASCE Annual Convention, are abstracted here. In addition to the moderator, Edward J. Cleary, M. ASCE, Executive Director and Chief Engineer of the Ohio River Sanitation Commission, Cincinnati, Ohio, the panel consisted of Samuel A. Greeley, Hon. M. ASCE, member of the firm of Greeley & Hansen, Chicago, Ill.; Francis S. Friel, Director of ASCE and President and Treasurer of the Philadelphia firm of Albright & Friel, Inc.; George Schroepfer, M. ASCE, Professor of Sanitary Engineering, University of Minnesota; George Steinmetz, M. ASCE, Chief Engineer, State Public Service Commission, Madison, Wis.; and Thomas Niles, M. ASCE, Engineer, Greeley & Hansen, Chicago.

IN OPENING the discussion, Moderator Cleary called attention to the special fitness of the members of the panel to discuss the topic assigned to it, "Financing Sewage Treatment Plants: How to Pay for New Plants Under Today's High Costs." Each of them, he said, had been engrossed with financing questions since 1948 as representatives of ASCE on a joint committee with the American Bar Association and six other groups in the development of the authoritative report, *Fundamental Considerations in Rates and Rate Structures for Water and Sewage Works*. Mr. Cleary then asked Mr. Greeley to discuss the question of whether there is a preferred or best way for municipalities to finance sewage disposal improvements.

MR. GREELEY: In a narrow sense of the word, there is no "best" way for municipalities to finance sewage disposal improvements. Obviously there are many local conditions that affect the means available to municipalities. In my opinion, there is a best way—a way that should be approached to the full extent of the possibilities of local conditions. That way was stated by the joint group to which the Moderator has referred as a sort of fundamental principle.

The statement of the group reads, "The needed total annual revenue of a water or sewage works shall be contributed by users and non-users and properties for whose use, need and benefit the facilities of the works are provided approximately in proportion to the cost of providing the use and the benefits of the works." I think the statement means that those who use facilities benefiting from a water or sewage works should pay approximately to the extent they have caused the expenditure for the desired facilities.

MR. NILES: Whatever method of financing is adopted, it is desirable that present owners and beneficiaries do not carry too much of the load for the benefit of future generations.

MR. FRIEL: In regard to the distribution of original costs among users and non-users, the costs of sewers and treatment works, which relate to the system as a whole, should be put in one classification, and the funds necessary to support that cost should be raised from one source. Then there are the costs incurred in the construction of branch sewers on individual streets to serve individual properties. Those costs should be put in another category and the costs allocated to the persons benefiting by the sewers. Last, of course, there are the service charges, which constitute an annual charge to be levied in support of the other two costs.

With today's high construction costs, it is necessary to divide costs in some such fashion as has been described in accordance with the so-called three-point method.

MODERATOR CLEARY asked Mr. Schroepfer to develop more fully a statement from the joint report to the effect that the exclusive use of any one method of financing will result in inequities or unfairness.

MR. SCHROEPFER: All of us probably realize that at least two-thirds of the industries discharge through municipal sewers and that industry influences, and sometimes actually controls, whether a project goes ahead or not. To approach fairness to all classes of users and property in allocating the cost, for example, of an intercepting sewer, ground-water infiltration, surface runoff, and the provision that is made for the future are proper charges on property, and the contribution of sewage and industrial wastes is a proper charge on the user. It is possible in a particular project to go through and first allocate those costs to users and properties and then to work up a rate schedule for distributing those allocations. If all the charge is put on a property basis, certain properties, such as home owners, then pay considerably more than their fair share. If it is put on a use basis, as is the case when volume or pollution contribution is the basis, then industries pay far more than their fair share.

MODERATOR CLEARY asked Mr. Niles to comment on the question as to whether general-obligation bonds are running at the present time about one-half of 1 percent less than revenue bonds.

MR. NILES: At least in some states the municipality in issuing revenue bonds can provide in the ordinance that the debt service be met by collections from charges to those benefited. Furthermore, the city guarantees that, in case they are not sufficient to retire the obligation, the municipality stands back of the bond issue. For practical reasons, the revenues may be expected to be sufficient so that the city won't have to pay out any money as a result of its guarantee. However, there are places where that is permitted without adding the amount of the bonds issued to the amount of bonds within the bonded indebtedness limit. That results, as I understand it, in an appreciably lower rate of interest. It brings the interest on the revenue bonds down within the same range as the interest on general obligation bonds.

MR. FRIEL: The problem of financing sewerage costs must be divided into two parts. Financing the sewage treatment plant itself constitutes one type of problem. Financing a treatment plant and a sewerage system—the whole works—is another problem.

If we have to finance treatment works alone or if we have to enlarge an existing plant, then the problem isn't too great. You can usually finance such construction either by the issuance of general obligation bonds (if the debt limitations of the municipality are within the borrowing capacity of the loan) or by revenue bonds. The trend today is to do it by revenue bonds. The annual rental that must be imposed to finance the debt service and the operating costs of a new plant or a plant expansion will not be too great.

When we get to the problem of having to finance a sewage treatment works plus a sewer system, that is

plants under today's high costs

where we get into trouble with today's high costs. Costs will probably be double as far as the annual carrying charge is concerned. Debt service plus operation plus factor of safety will make it double.

Then ways and means must be devised of doing something beyond the general obligation bond or the revenue bond. That might be accomplished by assessing the cost of the sewers and, possibly, the sewage treatment plant against taxation. Enough should be collected from tax money to pay the carrying charge on those improvements. Then assess the cost of the individual sewer line in front of an individual house against that property as a lump-sum assessment. The carrying charges in so far as operation is concerned, and the surplus necessary might be borne by sewer rental.

Thus you have a three-pronged method of financing. What you are doing actually is reducing your annual rental by paying a lump-sum down payment on your assessment, and I believe that is the proper way to do it under today's conditions.

MODERATOR CLEARY: Are there any comments from the floor?

CHARLES A. EMERSON (New York): During the past few weeks I have been having tussles with a number of bond attorneys. One of them took the attitude that the pronouncement of the Superior Court in one of our nearby states some years ago was to the effect that all of these financing methods were but thinly veiled subterfuges to raise taxes, and that the real criterion, whether it be *ad valorem* taxes or revenue bonds, is the ability of that municipality to pay in the opinion of the bankers. In the final analysis, if any of these bond interests are repudiated by the municipality, then it is the bankers who are sold these bonds and who resell them, and it is the public that bears the burden.

The simple, bald question is, how much can taxes be raised, because that is what John Q. Public looks at. He adds his general tax bill, his water bill, and his sewer rental bill together. How are we going to raise taxes enough to cover these expensive construction and operating costs? You have got to throw it all into the pot. How can you make the public pay, as viewed by the bankers who buy the bonds?

MODERATOR CLEARY: Mr. Greeley, would you comment on that?

MR. GREELEY: The matter Mr. Emerson brings up was passed on by the highest court in New York State, in connection with the Buffalo case. They ruled that the two-part rate, one part based on use, the other part based on property, was not a tax; and they have been going along on that basis for the past twelve or fourteen years.

It seems to me one of the difficulties has been failure on the part of those of us who in the past explained the matter to the courts. If that had been done fully and fairly, we might have avoided the present confusion regarding rates and rate structures on water and sewage works. The ruling of the New York court is not necessarily the only ruling on that particular point. What is really needed is a more fundamental approach to the problem, so that those of us who have to pass on it will understand what is actually involved in the method of financing these works.

MR. SCHROEPFER: It occurs to me that Mr. Emerson was considering the problem of relieving the tax load. You realize that 80 percent of the communities finance all their sewage improvements by charges on property, which we do not think is fair. The two-part method is a happy compromise in that it puts at least part of the burden on the user instead of putting it all on property.

MODERATOR CLEARY then asked Mr. Steinmetz to comment on the question, "What can we do in those small communities where the installation of sewage disposal facilities involves huge per capita expenditures? In other words, is there any way to offset the penalty for smallness in size?"

MR. STEINMETZ: One of the things that can be done is for the small community to start taking care of sewage disposal in a small way. In many situations, primary treatment and sterilization will serve for a time until the community is able to do a better job and improve its sewage disposal facilities. This is particularly true if the stream on which the community is located is a large one.

MODERATOR CLEARY asked Mr. Greeley to answer the question, "If federal grants-in-aid or loans were made available to municipalities for sewage disposal improvements, on what basis would you determine who would get what?"

MR. GREELEY: I do not think there is any answer to the question. You will find it discussed in a 1936 publication of the National Resources Committee, entitled *Public Works Planning*. My feeling is that there shouldn't be any federal grants to local government agencies unless and except in times of emergency when the country as a whole needs that kind of thing.

MODERATOR CLEARY: Mr. Friel, do you share that belief?

MR. FRIEL: Yes, and I should like to develop that thought a little further by suggesting that possibly such grants and aid may come from the states and not from the federal government because the federal debt is so high in relation to the state debts. It is probably more appropriate for any further grants to come from the states, although I am not in favor of grants from either the states or the federal government.

MR. STEINMETZ: I know of no better way of encouraging the communities that have not constructed sewage disposal facilities to delay and ask for extension of time than to hold out hope of federal money some time in the future. That is one of the headaches of agencies that are trying to get backward communities to catch up. They hope that if they hold off a bit longer, somebody will help them get what other communities have already got for themselves.

MR. NILES: I suppose if the only reason a community has not gone ahead with sewage treatment is that it just couldn't figure a way to finance it, it might receive consideration if such a thing as federal grants-in-aid were put across. Generally, however, it seems to me grossly unfair to the community that has gone ahead and paid for its own pollution correction to have its upstream neighbor get some government money that gives it a free ride.

Level of engineering education must be raised

ENGINEERING education in America was not developed after a preconceived plan. It evolved in parallel with the needs of a growing country, a country engaged in the development of a vast industrialization. From the first it filled a practical need, and its design emanated largely from an evaluation of the professional requirements.

From the earliest days the program was limited to four years. A very few schools added one or two years, with an additional degree. The medical, legal and architectural professions have extended their length of program to meet their particular objectives. The sciences, without exception, have been obliged to extend their programs through the addition of graduate work. Today no scientist is considered adequately trained without the doctor's degree. Whether graduate work is an appropriate program for the professional engineer is one of the questions dealt with [here].

Probably the most significant single characteristic of the engineering educational field is that it has no generally accepted professional objective as a goal for the educational program. There is general agreement respecting the form of the curriculum. The major differences lie in the depth of instruction and in the objective of each institution in respect of the professional outlook to be achieved. There exists today a spectrum of objectives ranging from highly professional programs supported by strong science backgrounds to vocational programs in which only a moderate amount of science is included.

It is possible to divide the subjects included in any engineering curriculum into five groups, as follows:

1. Basic science (mathematics, physics, chemistry, biology).

2. Applied science (mechanics, thermodynamics, fluid mechanics, geology, circuit theory, properties of engineering materials, etc.).

3. Applied engineering (for example, internal combustion engines, structures, machine design, industrial electronics, foundry technology, plant design, etc.).

4. Administrative and managerial (cost control, industrial organization, labor relations, etc.).

5. General (liberal courses, to provide a general educational background). Curricula may vary in the emphasis placed upon any one group, and in the extent of dominance of one group over others.

Historically, applied engineering courses dominated the curriculum in the early years. Gradually the pattern of basic science courses was evolved and generally included. Shop courses were reduced to a minimum. From 1885 until the first World War, mathematics was stabilized in the older curricula, terminating with the calculus. Since then only a few schools have carried the subject further in civil, chemical, mining, and mechanical engineering, while many schools have required additional mathematics in electrical engineering. Except in chemical engineering, and in some cases of mining engineering, the amount of chemistry required has been limited to general inorganic chemistry.

The time requirement in physics has remained nearly constant in most curricula since about 1885. In civil and mechanical engineering the amount of physics is limited to one year in most schools; and in many the same limit is found in electrical and chemical engineering. Generally, however, the approach from the point of view of atomic and molecular structure is needed but wanting.

The time devoted to mechanics is similar in nearly all schools. The variation in effectiveness of the course is not due to allotted time so much as to the depth of instruction. For many years it was the custom to minimize the use of the calculus in this subject. In civil engineering dynamics is regarded as being unnecessary, yet fatigue is becoming more important in structural design.

Hydraulics used to be taught from the empirical standpoint. Between the two wars there was pressure, emanating from the aeronautics field, for instruction in fluid mechanics. Some schools dealt sincerely with this proposed change; but many others simply changed the course name from hydraulics to fluid mechanics.

Factors of Major Significance

Many perplexing problems stem from the fact that the engineering college, in preparing students for professional work that will reach maximum culmination twenty or more years hence, must evaluate hazily discernible future events. Apart from the teaching of the professional attitude toward engineering and the instilling of the engineering and scientific method of attack upon problems, there are certain specific features of the curriculum that can be accepted as most essential.

The first of these has to do with courses least likely to obsolesce. While it is necessary to give a certain amount of instruction relating to the present state of the art, it is certain that the present state will change. Instruction in the basic sciences if taught in a manner such that knowledge of them makes available working tools, contributes the most sustaining part of the curriculum. Among these basic sciences, the greatest potential for future development in science and technology is to be found in mathematics. Mathematics not only becomes the support of the group of courses that will obsolesce least; it becomes the means of further technical growth as befits the graduate's interest and need. Building into the program this and other means for technical self-development of the individual after graduation is the second most important feature of a well-designed curriculum.

Need for giving students a greater knowledge of basic sciences and increased capacity for self-development and creative thinking was stressed in 1951 Annual Report of the ECPD Committee on Adequacy and Standards of Engineering Education, here excerpted.

MEMBERS OF COMMITTEE on Adequacy and Standards of Engineering Education of Engineers' Council for Professional Development (ECPD), who prepared the report here excerpted, are:

S. C. HOLLISTER, M. ASCE Chairman; Dean of Engineering, Cornell University, Ithaca, N. Y.

C. S. CROUSE, Head, Department of Mining and Metallurgical Engineering, University of Kentucky, Lexington, Ky.

I. F. GRANT, Field Secretary, The Engineering Institute of Canada, Toronto, Ont., Canada

M. D. HOOVEN, Electrical Engineer, Electrical Engineering Department, Public Service Electric and Gas Company, Newark, N. J.

The third feature of ranking importance has to do with the way in which the applied courses are related to those in basic and applied science. Two distinct approaches are discernible in present practices: one utilizes the engineering situations provided in the applied courses to illustrate the manner of employing the sciences in engineering work, while the other makes the applied courses the goal of the curriculum with the minimum of application of the sciences. The former builds into the student a power of analysis and resolution in engineering situations that permits a wide range of application. The latter tends toward the achievement of a series of skills intended to equip the student for specific jobs. The first is professional preparation, the second vocational training.

Following the concept that the differentiating characteristic of the engineering function is the ability to utilize the sciences for the creative process of design and development of useful apparatus, structures or other works, the program should aim at the development and expansion of the imaginative process of creative thought. Engineering educational processes are most commonly of the problem type, requiring but a single answer, with no latitude for judgment, and no imaginativeness beyond the visualization of the circumstance of the problem. Programs in architecture far surpass those in engineering in this respect. We tend toward producing a literal-mindedness that is not compatible with creative imagination.

It is believed that quantitative specifications for engineering curricula are not adequate as guides to curriculum planning because they tend toward regimentation, toward fixation, and toward eventual stagnation of awareness of the professional needs.

Engineering is both a science and an art. A balance between both is desirable. The tendency has been to emphasize the art unduly. The "engineering approach" can be presented in the manner in which science is brought to bear on an engineering situation. Much of the art can better be acquired in the field.

Suggested Program

The quality of engineering curricula varies over a wide range, from highly developed professional programs to those having a predominantly vocational content. The foregoing discussion relates especially to the middle and lower portion of the range. Accrediting procedures relate almost entirely to the minimum standards, and tend to breed complacency among those schools that just barely satisfy such a standard. While accrediting must be maintained as a part of the licensing procedure, it cannot be expected that accrediting of itself will achieve the improvement of schools that satisfy the minimum requirements unless two or more classes of schools were established and accrediting set up for each class. Such a scheme would neither be welcome nor desirable. Rather, the engineering educational field has a great opportunity to study itself, with the object of finding ways at all levels to improve its service to the profession. What is now needed is active study and self-appraisal by the schools themselves, looking toward implementation of recommendations already made.

The basic program in engineering leading to the first degree in the field should be of a quality to suffice for the professional need of perhaps 80 percent of the graduates. Truly graduate work should be reserved for the remaining few having special competence. The responsibility for support of the profession must rest chiefly upon the adequacy of the undergraduate program.

The great pressure upon the engineering schools to provide general education in addition to an increased scientific and technical training brings them constantly face to face with the limitation in time imposed by the conventional curriculum. It is perhaps time that this problem was approached in terms of total need; and then the time required to achieve this need be measured beginning with the preparation now available from the secondary schools. For many years the approach has been to see what can be given within the four-year framework, with the result of over-crowding the program and with a general shifting first in one direction and then another without total gain in achievement. Other professions have had to face this issue. If engineering maintains professional stature, it will have to organize accordingly. Some have suggested a pre-engineering period in which the high school preparation may, if necessary, be augmented to a desired level before beginning engineering study.

Finally, it becomes clear that there is going to be a shortage of engineers for many years to come. At such a time, in the national interest, it is of paramount importance that the best possible education in engineering be provided by our schools. Each man is going to be called upon to cover a greater range than heretofore, if the engineering needs are to be met. Every school should devote itself to ways of substantial improvement of its program, to the end that its graduates will meet the responsibilities being placed upon them.

Power facilities at South Holston Dam include submerged intake

THIS article describes the over-all layout of the power installation at the South Holston project, constructed by the Tennessee Valley Authority, and explains the steps leading to the adoption of some features not commonly found on a project of this type.

THE SOUTH Holston project, located on the South Fork of the Holston River, near Bristol, Tenn., is a multipurpose project for flood control and power. The drainage area is 703 sq miles, and the average unregulated flow is 1,020 cfs. The reservoir provides 550,000 acre-ft of controlled storage available for power, and an additional 110,000 acre-ft reserved for flood control. The head varies from a maximum of 257 ft to a minimum of 127 ft. The dam, with a height of 290 ft, is of earth fill with rock fill shoulders. The flood outlets are located on the left bank, and the power installation is on the right bank.

The annual firm power output at the site is 136,000,000 kwhr. In addition, the regulating effect on the stream flow will make available annually 311,000,000 kwhr of firm power at downstream plants. When the project was first authorized in 1942, studies indicated the advisability of installing facilities to accommodate initially two 25,000-kw units, with provision for a third such unit in the future. Later power studies reduced this to two units, and finally to one unit of 35,000-kw capacity.

The earliest plan, developed under wartime restrictions on critical materials, notably steel, proposed a dry tower intake, an 18-ft dia concrete-lined tunnel through the right abutment, a concrete-lined surge tank excavated in rock, and an indoor-type powerhouse located at the toe of the dam. Work on that plan was halted by the War Production Board before much progress had been made on the design of the power facilities. Later and more extensive investigations of geologic conditions showed the rock to be of such poor quality that a surge tank excavated in rock would be inadvisable.

Three Alternative Plans Studied

Postwar studies included three alternative plans. One proposed a short penstock and a powerhouse located in a cavity excavated in the right abutment, and a long tailrace tunnel to the river below the dam. The second plan proposed a concrete-encased steel penstock under the dam without a surge tank, and the third plan proposed a steel-lined tunnel with a steel surge tank built above rock. Plan 1, although highly satisfactory from an operational standpoint, involved a large quantity of expensive excavation. The purpose of Plan 2 was to shorten the penstock sufficiently to eliminate the need for a surge tank. This shortening was achieved by carrying the penstock on a straight line under the dam. To obtain the desired generator-speed regulation required a considerable increase over the normal rotating inertia, or wr^2 of the generator. This in turn increased the size of the powerhouse and required a larger crane, so that the over-all cost of this plan became high.

Comparison of the three plans led to the adoption of Plan 3 as the most economical. Comparative estimates then were made for various types of component structures. For the intake, a comparison between the costs of a wet tower intake with caterpillar gates and a submerged chamber containing a butterfly valve, led to the adoption of the submerged-type intake. A comparison of a differential surge tank and a restricted-orifice tank led to the adoption of the restricted-orifice type. The general layout of the intake, the power conduit with the surge tank, and the powerhouse is shown in Fig. 1.

The first layout of the intake was a conventional U-shaped tower providing for the setting of a tractor-type gate with hoisting and handling machinery. Because of the large fluctuations of the headwater at this project, from El. 1616 to El. 1753, the tower would have had to be about 180 ft high and the whole layout would have been rather costly. Instead, a butterfly-valve installation was found to be the least expensive and most reliable means of headwater control, and it was adopted. Only a watertight chamber for housing the valve and the controls, and a means of access were required. A saving of $260,000, as compared to the more conventional layout, was realized.

The general arrangement of the intake and access is shown in Fig. 2. The intake consists of a chamber with inside dimension of 18.5 ft by 32 ft by 32 ft high, containing the 180-in. motor-operated butterfly valve and the necessary auxiliary equipment. The valve is operated by a 7.5-hp d-c motor and designed to fully close or open in 6 min. It can also be operated by hand in case power is not available. No provision was made for moving the disk or the housing out of the chamber, as it is very unlikely that the need to do so will ever arise. Downstream of the butterfly valve are installed a vacuum relief valve and an 8-in. penstock vent.

Access to the chamber is through a culvert 7 ft high by 6 ft 6 in. wide, which slopes up the hillside and ter-

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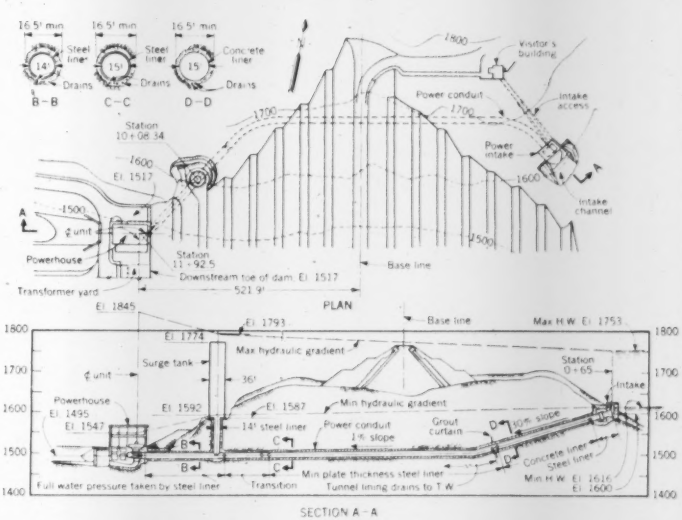
FIG. 1. POWER FACILITIES at TVA's South Holston Dam include submerged power intake; partly steel-lined pressure-tunnel penstock 15 ft in diameter, bored through right abutment; restricted-orifice steel surge tank; powerhouse with a single 48,500-hp turbine; and outdoor transformer and switch yard.



minates in the basement of the visitors' building. The culvert is trenched into the rock. The thicknesses of the walls and slabs of the culvert were set at a minimum of 3 percent of the hydrostatic head to reduce seepage. The culvert contains tracks for a two-man cable car and a stairway for emergency use. This inclined access culvert was found to be less expensive than a vertical elevator shaft and horizontal tunnel.

Two 8-in. pipes located in the power tunnel invert drain the valve chamber to the tailrace. The drains have two inlets each, one at the floor level and one up on the wall to prevent flooding of the chamber to more than about a 2-ft depth in case the floor inlets become clogged by an accumulation of waste.

The valve chamber is ventilated by a fan in the visitors' building, which forces air down through an 8-in. pipe to the chamber and exhausts it back up the access culvert.

Percolation rings around the penstock sections at both the upstream and downstream walls of the chamber also act as thrust rings to resist the reaction from the butterfly valve. Stiffener rings at the downstream end of the steel liner prevent buckling due to outside hydrostatic head when the conduit is unwatered. During unwatering operations the penstock is subject to a partial vacuum equal to about 5 ft of hydrostatic head. Inside the valve chamber, where the liner is free to deform, a plate thickness of 1 in. was required to prevent buckling.

Both the chamber and the access culvert were coated on the outside with two coats of waterproofing as an extra precaution against seepage. A stop-log slot at the upstream face of the intake will allow closure at low headwater elevations to permit inspection and repair of the butterfly valve and the intake penstock.

The trashrack structure, built against the sloping upstream face of the intake valve chamber, consists of a semicircular-shaped framework of concrete columns and struts supporting steel trashrack sections. The structure is proportioned to give a maximum velocity through the gross area of the trashracks of 2.8 fps and is designed to withstand an unbalanced hydrostatic head of 10 ft.

A short approach channel was excavated upstream of the intake for efficient operation at low headwater elevations. The view on the following page (Fig. 2) shows the completed intake and the access culvert.

Penstock Tunnel in Abutment Rock

The penstock tunnel was located through the abutment of the dam so that it would not interfere with the building of the dam. The space available for the powerhouse was confined within narrow limits on the right bank of the river. The powerhouse was set into the toe of the dam to shorten the power conduit.

Within the limitations of the intake and powerhouse locations, various alignments for the penstock tunnel were investigated, the principal considerations being safety and economy. The following factors determined the final location: (1) The overburden on the major part of the tunnel had to be sufficient to withstand the hydrostatic head, the minimum height of overburden required without dependence on the steel liner being 50 per cent of the hydrostatic head; (2) the profile of the tunnel required a continuous slope from the intake to the powerhouse for unwatering; (3) the horizontal and vertical alignment had to give minimum head losses.

Studies of friction losses in penstock tunnels of various sizes gave the most economical diameter as 15 ft in the part where the overburden was sufficient to withstand the full hydrostatic head, and 14 ft where the steel liner was required to carry part or all of the hydrostatic load. It was feared that a concrete lining would crack, permitting water to leak through sandstone layers into the earth core of the dam and cause piping. This undesirable possibility was prevented by extending the steel lining through the area from which leakage might reach the core.

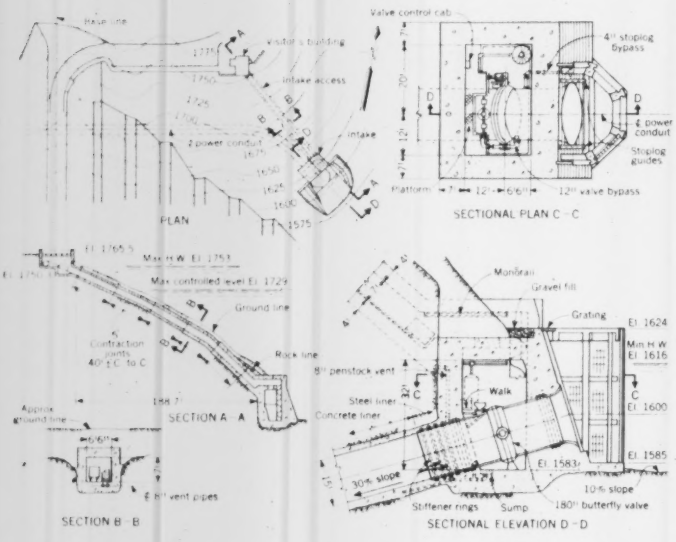
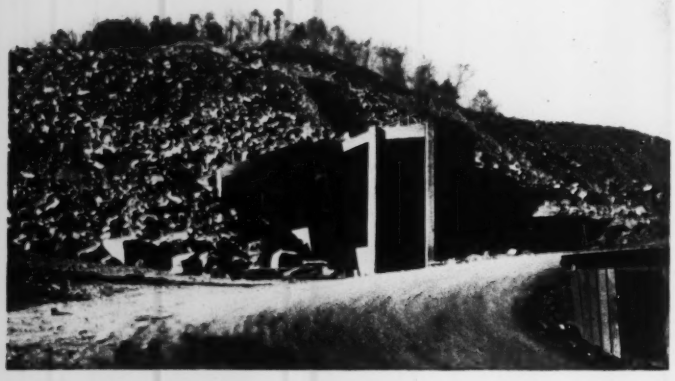


FIG. 2. SUBMERGED POWER INTAKE is controlled by single 180-in. butterfly valve operated by 7½-hp remote-controlled motor. Motor is set in watertight chamber, reached through inclined culvert with entrance above reservoir level. Normal reservoir operating level is 150 ft above roadway shown in photograph.



To permit transportation of the steel liner rings into the tunnel from the downstream portal, the tunnel was bored to a diameter of 16.5 ft, giving a minimum cover of 9 in. around the liner. The invert was enlarged to a horseshoe shape to accommodate drain pipes and rails for transporting the liner segments into place.

The upstream 547 ft of the liner is made up of $\frac{7}{16}$-in. steel plate. Investigations indicated that this plate would buckle under an external pressure of 85 ft of head. The maximum external pressure, corresponding to full reservoir at El. 1,753, is about 250 ft of head. To construct the liner strong enough to prevent buckling under a maximum external head of 250 ft when the tunnel is unwatered, would have required a heavy plate about $1\frac{1}{4}$ in. thick, or closely spaced stiffener rings. Instead of such construction, it was decided to prevent any substantial hydrostatic pressure from building up around the outside of the steel liner by placing continuous drain pipes along each side of it. These pipes drain to tailwater. The drains are bell-and-spigot concrete pipe laid with open joints and encased in a collar of porous concrete.

A grout curtain was placed at the upstream end of the liner by drilling holes 10 ft deep into the rock and grouting under pressure. Just downstream of the grout curtain, a concrete drain pipe was laid around almost the full circumference of the liner and connected to the longitudinal drains. Grout holes were provided in the top of the steel liner, spaced about 8 ft on centers. After erection and concreting of the liner, these holes were drilled through the surrounding concrete to rock and grouted under a pressure of 10 psi to ensure continuous contact between the liner and the concrete and to fill voids between the concrete and the rock. The precautions mentioned above are expected to eliminate any danger of buckling of the steel liner.

Between the downstream tunnel portal and the powerhouse, a 52-ft length of the steel penstock is encased in an envelop of reinforced concrete which carries the surcharge from the rock-fill dam.

Two layouts were investigated for the surge tank: one for an elevated

tank immediately upstream of the powerhouse, and the other for a tank supported on a slab poured on solid rock, the tank being connected to the penstock by a vertical shaft excavated in rock. The second arrangement was less expensive, and the regulating characteristics were satisfactory. If a differential tank were used, it was estimated that the internal riser would cost approximately $50,000. Preliminary comparative design indicated that a restricted-orifice tank of the same diameter would give operating characteristics very similar to those of the differential type. A model test of a restricted-orifice tank in the hydraulic laboratory confirmed the results of the design, and this type of tank was adopted.

Some concern was felt as to the effect of the restricted orifice on the water-hammer, but design investigation indicated that this was of minor importance and the prototype test, made with instruments for measuring water-hammer, proved this. A paper containing the results of the model and prototype tests was presented by R. A. Elder, M. ASCE, at the June 1951 Summer Convention of the ASCE in Louisville, Ky.

The tank was proportioned for 100 percent load demand or rejection with a 5-sec governor time. The orifice was proportioned to produce an immediate pressure change and then maintain it nearly constant in the first quarter cycle in order to minimize pressure oscillations in the conduit and prevent the governor from "hunting." The welded steel tank is 36 ft in diameter and 187 ft high, with the top elevation set about 6 ft above the maximum surge and the base elevation about 6 ft below the minimum surge. The surge-tank base is a 5-ft-thick concrete pad poured on rock. The bottom of the tank is separated from the concrete foundation by a $1\frac{1}{2}$-in. layer of sand to allow for contraction and expansion of the tank.

The longitudinal axis of the powerhouse was made perpendicular to the axis of the dam to utilize the space over the draft tube for service facilities. The electrical bay is along the south side of the generator room adjacent to the transformer yard.

The powerhouse is remotely controlled from a center about 18 miles from South Holston, which also controls the Watauga and Wilbur powerhouses. (See article by Don H. Mattern, M.ASCE, CIVIL ENGINEERING for August 1951, p. 46.) Thus three plants with a total installed capacity of 94,500 kw are controlled from one center.

For a station housing two units or less, in the experience of the TVA, the indoor type of powerhouse has proved less costly than the semi-outdoor or outdoor type. This is partly because of the higher cost of the outdoor-type crane, and the fact that the enclosed erection space available on the generator-room floor with an indoor-type powerhouse, will have to be provided somewhere else when an outdoor or semi-outdoor powerhouse is used.

The South Holston powerhouse is of the indoor type, with the entrance at the generator-room floor level. The general layout is shown in Fig. 3. The substructure is reinforced concrete, and the superstructure is structural steel framing with insulated aluminum Q-panel walls. The roof is steel Q-decking covered with 1 in. of insulation, topped by built-up roofing and a thin layer of gravel. This type of siding and roof was chosen for economy and speed of erection. The powerhouse provides space for the vertical setting of one unit.

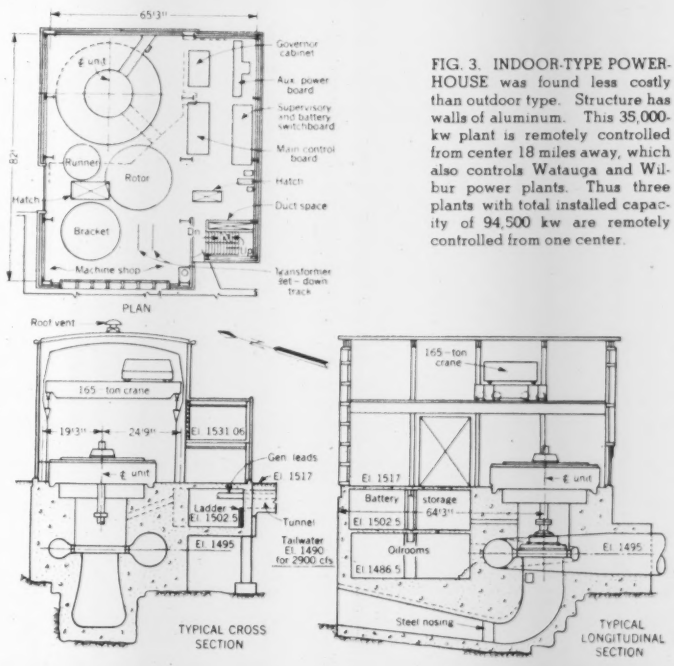
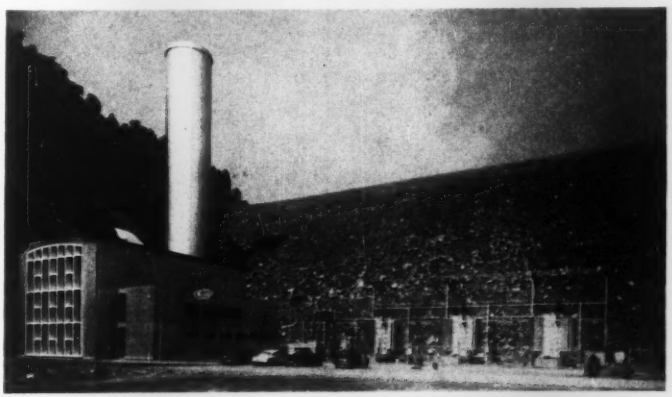


FIG. 3. INDOOR-TYPE POWERHOUSE was found less costly than outdoor type. Structure has walls of aluminum. This 35,000-kw plant is remotely controlled from center 18 miles away, which also controls Watauga and Wilbur power plants. Thus three plants with total installed capacity of 94,500 kw are remotely controlled from one center.



The turbine, a single-runner Francis type, is rated at 48,500 hp at full gate under an 180-ft net head at 144 rpm. The best efficiency is at a net head of 205 ft and an output of 48,500 hp. The runaway speed is 267 rpm, and the turbine is designed to withstand without damage the full runaway speed for 60 min. The spiral casing is of riveted steel-plate construction. The generator is rated at 38,800 kva at a temperature rise of 108 deg F. It is the completely enclosed air-cooled type, with the air in turn cooled by water-cooled heat exchangers.

The center line of the distributor is 7.5 ft above tailwater, with the unit running under normal conditions. With the unit shut down and no flow through the spillway or sluices, the river below the tailrace is dry. The tailrace and the draft tube can be drained into the station sump. The sump discharge outlet is into the river some distance downstream of the excavated tailrace, and consequently no draft tube gates are required.

The leads from the powerhouse are carried to the three single-phase transformers in a tunnel. To carry off the heat generated by the energized leads, air drawn from the basement in the electrical bay is forced through the tunnel. Single-phase transformers were used because of the difficulty of transporting and handling the heavier three-phase type. The transformers can be moved by a truck and trailer into the powerhouse for repairs.

Costs on this project, exclusive of general expenses, were approximately as follows:

Powerhouse	Structures	$ 740,000
	Equipment	1,850,000
		2,590,000
Surge tank		260,000
Water conductor		790,000
Intake and access		470,000

The station was placed in operation in February 1951.

All engineering and construction work for TVA is under the direction of C. F. Bliss, M. ASCE, Chief Engineer. R. A. Monroe, M. ASCE, is Chief Design Engineer. A. A. Meyer, M. ASCE, Chief of the Civil Design Branch of the Division of Design, has made many constructive contributions to this paper. The hydraulic testing was done under the supervision of R. A. Elder, Assoc. M. ASCE, Head of the TVA Hydraulic Laboratory at Norris, Tenn.

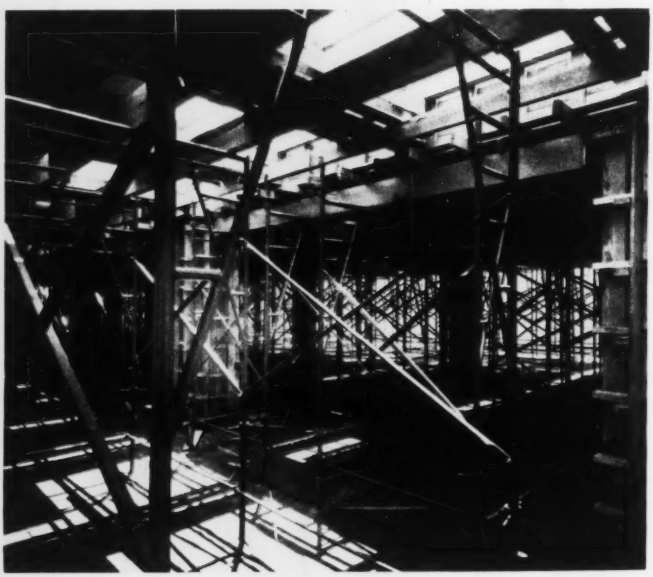
This article is based on the paper presented by Mr. Lavik at a Power Division session presided over by James P. Growdon, at the ASCE Annual Convention.

FIELD HINTS

Sectional steel pipe provides economical shoring

TO MEET the urgent need for simple low-cost shoring, a sectional steel pipe scaffolding is now being used by numerous contractors and has proven itself very adaptable. Typical of the scaffolding being used is Tube-Lox, a tube and coupler type, requiring only four basic components—interlocking tubes in various lengths, two types of couplers, and a base. The pipe scaffolding frames are about 5 ft wide and range in height from 3 to 10 ft.

Adjustable legs easily bring the forms into grade. The fire hazard is reduced, and material recovery is 100 percent. The danger of warping is also eliminated. Ease of handling and small labor force are additional advantages. Safe working loads range up to 366 psf for the sectional type of scaffolding, depending on the spacing between frames, type of frame, and location of blocking timbers on frames.



ENGINEERS' NOTEBOOK

Complex backwater problems solved by simple curves

IRVING JOSEPH, Assoc. M. ASCE

Hydraulic Engineer,

Harza Engineering Company, Chicago, Ill.

SIMPLE CURVES have been found very useful in the solution of backwater problems which formerly required long and careful trial-and-error calculations. Back in 1919, the late H. R. Leach, M. ASCE, presented some methods for the solution of backwater problems which since have been accepted and used frequently. One of his methods is shown in Fig. 1, in which curves for each reach are drawn, showing the elevation of the water surface at the head of the reach as compared with its elevation at the foot of the reach. These curves are used to obtain a graphical solution of backwater profiles for a known discharge with an indeterminate starting elevation. The data used in drawing the curves are obtained by any convenient method. Mr. Leach proposed the use of Kd curves in which the constants $\frac{1.486}{n} AR^{2/3}$ in Manning's formula are grouped into a constant. (See his article, "New Methods for the Solution of Backwater Problems," in *Engineering News-Record*, April 17, 1919.)

Several times the writer has been confronted with a more complex problem in which the discharge as well as the starting elevation was indeterminate. To facilitate the solution of this type of problem, the data in Fig. 1 were rearranged as shown in Fig. 2. In Fig. 2 there is a curve for each discharge, representing the elevation of the water surface at the foot of a reach versus the change in the water surface elevation in the reach. Note that a new set of curves is required for each reach. In the method which was presented by Mr. Leach, a new set of curves is required for each discharge.

The advantages obtained by arranging the data as in Fig. 2 are significant. They are as follows:

1. All computations up to the plotting of the data need not be checked. Any errors greater than several hundreths of a foot are easily detected by visual inspection. This is so because the group of curves forms a family relationship in which a smooth transition of change in curvature occurs from the low to the high discharges.

2. Use of the curves, once they are set up, saves a great deal of time in completing the backwater solution. The solution is direct. No trial-and-error computations are involved.

3. Continuous, errorless computations for the preparation of the data used to plot the curves is not required. Elimination of this requirement, a necessity in other methods, is in itself an important time-saving factor.

The writer has used curves like those in Fig. 2 for the solution of various backwater problems and has found that they result in a definite saving of time as compared with other methods, with no loss in accuracy.

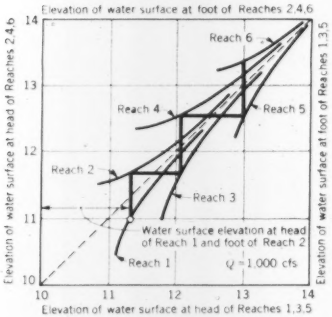

Elevation of water surface at foot of Reaches 2,4,6
Elevation of water surface at head of Reaches 2,4,6
Elevation of water surface at foot of Reaches 1,3,5
Elevation of water surface at head of Reaches 1,3,5
Reach 6
Reach 4
Reach 5
Reach 2
Reach 3
Reach 1
Water surface elevation at head of Reach 1 and foot of Reach 2
Q = 1,000 cfs
10
11
12
13
14

FIG. 1. CURVES show elevations of water surface at head and foot of six reaches at known discharge of 1,000 cfs with indeterminate starting elevation. (From "New Methods for the Solution of Backwater Problems," H. R. Leach, *Engineering News-Record*, April 17, 1919.)

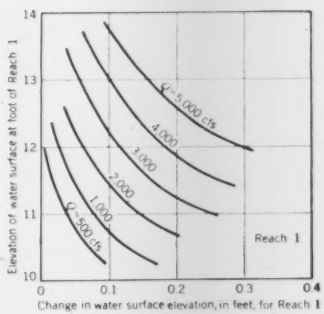


FIG. 2. CURVES solve backwater problem when initial water stage and discharge are not definitely known.

THE READERS WRITE

Reinforcement Recommended for Buttress-Type Dam

—TO THE EDITOR: In his discussion (September 1951, p. 54) of my article on a buttress-type dam with curved upstream face (June 1951, p. 50), L. A. Schmidt, Jr., anticipates that "construction joints" would limit the height of this type of dam. Perhaps he had in mind that the downstream deflection of the crest of the dam under full water pressure, by lengthening the arc of the concave curvature of the upstream slab

(*Continued on page 136*)

AMERICAN SOCIETY OF CIVIL ENGINEERS

NEW ORLEANS CONVENTION

ST. CHARLES HOTEL, NEW ORLEANS, LA. MARCH 5–7, 1952

REGISTRATION

Mezzanine Floor of St. Charles Hotel, opens Wednesday, March 5, 8:30 a.m.; each Convention day 8:30 a.m. to 5:00 p.m.

Registration fee (except ladies and students), $3.00

WEDNESDAY MORNING, MARCH 5

Welcome to New Orleans and General Business Session

10:30 A.M. BEAUREGARD ROOM, ST. CHARLES HOTEL

Presiding: Carlton S. Proctor, President, American Society of Civil Engineers

10:30 a.m. **Welcome by the Louisiana Section**
FRANK W. MACDONALD, Louisiana Section, ASCE

Welcome by the City of New Orleans
HONORABLE DE LESSEPS S. MORRISON, Mayor of the City of New Orleans

Response
CARLTON S. PROCTOR, President, American Society of Civil Engineers

11:30 a.m. **General Business Session of ASCE**
Award of Daniel W. Mead Prize to EDGAR G. BAUGH, Jun. M. ASCE, Houston, Tex.
Reports by Executive Secretary
New business

12:15 p.m. Adjournment for membership luncheon

MEMBERSHIP LUNCHEON

Wednesday, March 5

12:30 P.M. GRAND BALLROOM ROOSEVELT HOTEL

ROBERT W. ELSASSER, Business Counselor, will address the Convention. His subject will be "Political Variables in Engineering Administration."

DAVID W. GODAT, New Orleans Convention Chairman, will introduce the speaker.

All members, their ladies, guests and friends of ASCE are cordially invited to attend this luncheon. Price $3.00 per plate.

AUTHORS' BREAKFASTS

ROOM A, ST. CHARLES HOTEL

Wednesday, March 5, 8:15 a.m.

Thursday, March 6, 8:15 a.m.

Friday, March 7, 8:15 a.m.

Briefing sessions for all speakers, discussers and program officials by invitation. Presiding: BERNHARD M. DORNBLATT, Chairman of Technical Program.

HARBOR TRIPS

Board of Port Commissioner's Yacht "Good Neighbor"

March 6 and 7, 1952

For Members, Wives and Guests

Yacht leaves foot of Canal Street 2:30 o'clock each afternoon.

Early registration by members as to desired dates for trips is urged, as the yacht will accommodate only fifty passengers each trip.

WEDNESDAY AFTERNOON, MARCH 5

Division Sessions

Highway Division

2:30 P.M. ROOM D

Presiding: G. Donald Kennedy, Member, Executive Committee, Highway Division

2:30 **Development of Dual Drive on U.S. 90**
G. WALTON THOMPSON, Mississippi State Highway Department, Jackson, Miss.

3:15 **Highway Bridges on Deep Foundations**
LOUIS C. DUCLOS, M. ASCE; Head Bridge Designer, Louisiana State Highway Dept., Baton Rouge, La.

Sanitary Engineering Division

2:30 P.M. ROOM A

Presiding: B. A. Poole, Member, Executive Committee, Sanitary Engineering Division

2:30 **Sanitary Engineering Activities in the Atomic Energy Commission**
JOSEPH A. LIEBERMAN, Assistant Sanitary Engineer, U. S. Atomic Energy Commission, Washington, D.C.

3:00 **Engineering Problems of Paper Mill Wastes Disposal**
HARRY GEHM, National Council for Stream Improvement, New York, N.Y.

3:30 **Stream Pollution Abatement Problems of Industry**
L. L. HEDGEPETH, Technical Consultant, American Cyanamid Co., Bound Brook, N.J.

Structural Division

2:30 P.M. JACKSON ROOM

Presiding: George E. Brandow, Member, Executive Committee, Structural Division

2:30 Design for Offshore Petroleum Installations

G. W. OSBORNE, Engineer, The California Oil Co., New Orleans, La.

3:00 Louisiana's First All-Welded Continuous Overpass

W. E. BLESSEY, M. ASCE; Professor of Structural Engineering, Tulane University, New Orleans, La.

3:30 Prestressed Concrete

E. J. BRINKMAN, Board of Commissioners of the Port of New Orleans, La.

Waterways Division

2:30 P.M. BEAUREGARD ROOM

Presiding: DeWitt L. Pyburn, Chairman, Executive Committee, Waterways Division.

2:30 Arkansas-White-Red Basins Inter-Agency Committee

L. M. PRENTISS, Col., U.S. Corps of Engineers; Division Engineer, Southwestern Division, Dallas, Tex.

3:00 A Comprehensive Report on the Arkansas-White-Red Basins

J. B. LAMPERT, Lt. Col., U.S. Corps of Engineers; Officer-in-Charge, Southwestern Division, Tulsa, Okla.

3:30 Port of Lake Charles

ELMER E. SHUTTS, M. ASCE; Consulting Engineer, Port of Lake Charles, La.

4:00 Harbor Project for the Oil Port of Maracaibo, Venezuela

E. F. ROBINSON, M. ASCE; Consulting Engineer, Winchester, Va.

DINNER AND DANCE

CLAIBORNE-BEAUREGARD ROOMS, ST. CHARLES HOTEL

Wednesday, March 5

7:00 Cocktails

8:00 Dinner

9:30 p.m. Dancing and Entertainment

SPEAKER: FRANK W. EDWARDS, General Manager, Centennial of Engineering, 1952. TOPIC: "Centennial of Engineering"

Special arrangements can be made for tables seating 8 or more persons. Members may underwrite complete tables. Orders for tables must be accompanied by a check in full and a list of guests.

The published seating list will close at 5:00 p.m., Tuesday, March 4. Tickets purchased after this hour will be assigned to tables in order of purchase. Sale of tickets will continue until 5:00 p.m., Wednesday, March 5. Dress will be formal. Tickets $8.00 per plate.

PLANNED TOURS

Busses leave the St. Charles Hotel at times scheduled below. Tickets at Registration Desk, $1.00 each.

Tour No. 1

Wednesday, March 5, 1952, 2:30 p.m.

New Orleans Water Purification Plant
Sewerage and Water Board Drainage Pumping Station No. 7 (largest in the world)
Lakeshore Drive
Metairie Cemetery

Tour No. 2

Thursday, March 6, 1952, 1:30 p.m.

New Orleans Railroad Terminal Board's Construction Projects:
(*a*) New Terminal Station
(*b*) Track Rearrangements
(*c*) Grade Separations

Tour No. 3

Wednesday, March 5, 1952, 2:30 p.m.

New Orleans Public Service, Inc. Industrial Canal Power Plant
Lakeshore Drive

Tour No. 4

Thursday, March 6, 1952, 2:30 p.m.

College of Engineering
Tulane University Campus

THURSDAY MORNING, MARCH 6

Division Sessions

City Planning Division

9:30 A.M. ROOM A

Presiding: Harry W. Alexander, Chairman, Executive Committee, City Planning Division

9:30 Analysis of City Planning Techniques

RUSSELL RILEY, M. ASCE; Partner, Harland Bartholomew & Associates, St. Louis, Mo.

10:00 Proposed Mississippi River Parkway from Canada to the Gulf of Mexico

J. LESTER WHITE, M. ASCE; Department of Public Works, State of Louisiana, Baton Rouge, La.

10:30 Recent Airport Design and Developments

PHILIP A. HAHN, Chief, Airport Engineering Division, Civil Aeronautics Admin., Washington, D.C.

Soil Mechanics and Foundations Division

9:30 A.M. CLAIBORNE ROOM

Presiding: Willard J. Turnbull, Member, Executive Committee, Soil Mechanics and Foundations Division

9:30 Foundations in the New Orleans Area

H. A. HUESMAN, U.S. Corps of Engineers, New Orleans District

10:00 Soils Investigations for Offshore Drilling Platforms in the Gulf of Mexico

BRAMLETTE MCCLELLAND, Jun. M. ASCE; Humble Oil & Refining Co.

10:30 Highway Embankments on Yielding Subsoils

H. L. LEHMANN, Testing Engineer, Louisiana Department of Highways

Structural Division

9:30 A.M. JACKSON ROOM

Presiding: George E. Brandow, Member, Executive Committee, Structural Division

9:30 Welded-Frame Multi-Store Buildings

BOYD S. MYERS, M. ASCE; Associate, Robert J. Cummings, Consulting Engineer, Houston, Tex.

10:00 Tampa Bay Bridge

MAURICE N. QUADE, M. ASCE; Parsons, Brinkerhoff, Hall and Macdonald, Consulting Engineers, New York, N.Y.

10:30 Bay St. Louis Bridge

CRAIG P. HAZELET, M. ASCE; Consulting Engineer, Hazelet and Erdal, Louisville, Ky.

Waterways Division

9:30 A.M. BEAUREGARD ROOM

Presiding: DeWitt L. Pyburn, Chairman, Executive Committee, Waterways Division.

9:30 Passes of the Mississippi River

W. C. COBB, M. ASCE; U.S. Corps of Engineers, Operations Division, New Orleans, La.

10:00 Flood Control Plan for the Mississippi River

J. C. BAEHR, M. ASCE; U.S. Corps of Engineers.

10:30 Wave-Wash Control on Mississippi River Levees

RUDOLF HERTZBERG, M. ASCE; U.S. Corps of Engineers, Engineering Division, New Orleans, La.

11:00 Maintenance of Rights-of-Way

J. R. BARGAS, SR., M. ASCE; U.S. Corps of Engineers, Engineering Division, New Orleans, La.

CONVENTION LUNCHEON

THE ST. CHARLES HOTEL 12:30 P.M.

Thursday, March 6

Tickets $3.00

THURSDAY AFTERNOON, MARCH 6

Division Sessions

Joint Session—City Planning Division with the Institute of Traffic Engineers

2:30 P.M. ROOM A

Presiding: Harry W. Alexander, Chairman, Executive Committee, City Planning Division

2:30 **Traffic Problems of New Orleans**

KENNETH KING, City Traffic Engineer, New Orleans, La.

Power Division

2:30 P.M. JACKSON ROOM

Presiding: Byron O. McCoy, Chairman, Executive Committee, Power Division

2:30 **Economics in Steam-Electric Station Design in the New Orleans Area**

A. T. LARNED, M. ASCE, Chief Civil Engineer, Ebasco Services, New York, N.Y.

3:00 **Water Power and Aid to the Improvement of Water Resources in the Onachita Basin**

FORREST J. BROWN, A.M. ASCE, U.S. Corps of Engineers, Lower Mississippi Valley Division, Vicksburg, Miss.

Soil Mechanics and Foundations Division

2:30 P.M. CLAIBORNE ROOM

Presiding: Willard J. Turnbull, Member, Executive Committee, Soil Mechanics and Foundation Division

2:30 **Settlement Observations of Sulphur Storage Vats Compared to Predicted Results**

J. B. EUSTIS, M. ASCE, Eustis Engineering Co.

I. E. HANSON, Chief Engineer, Freeport Sulphur Co.

3:00 **Progress Report of Soil Mechanics and Foundation Committee of the Louisiana Section**

Hydraulics Division

2:30 P.M. BEAUREGARD ROOM

Presiding: George R. Schneider, Member, Executive Committee, Hydraulics Division

2:30 **Prototype Testing Program of the TVA**

REX A. ELDER, A.M. ASCE, Hydraulic Engineer, Tennessee Valley Authority, Norris, Tenn.

3:15 **Prototype Testing Program of the Bureau of Reclamation**

DALE M. LANCASTER, A.M. ASCE, Hydraulic Engineer, Bureau of Reclamation, Denver, Colo.

4:00 **Prototype Testing Program of the Corps of Engineers**

FRANK B. CAMPBELL, M. ASCE, Hydraulic Engineer, Waterways Experiment Sta., Vicksburg, Miss.

Atomic Test Motion Pictures

2:30 P.M. ROOM D

The motion picture *Sandstone*, depicting the series of atomic tests on Eniwetok will be shown by special arrangement.

BOAT RIDE ON THE MISSISSIPPI RIVER

Thursday, March 6

Members Ladies Guests

"Steamer President" leaves foot of Canal Street at 8:00 p.m.

Music Dancing Cocktails

Tickets at Registration Desk, $2.50

FRIDAY MORNING, MARCH 7

Division Sessions

Construction Division

9:30 A.M. CLAIBORNE ROOM

Presiding: Ross White, Member, Executive Committee, Construction Division

9:30 **Construction of the New Orleans Union Passenger Terminal**

E. J. WALLACE, Chief Engineer, New Orleans Union Passenger Terminal.

10:00 **New Jersey Turnpike—Construction Methods, Plant and Equipment**

S. C. FUNK, Construction Engineer, New Jersey Turnpike Authority.

C. H. PETERSON, A.M. ASCE, Project Manager, Howard, Needles, Tammen and Bergendoff.

10:30 **The Missouri-Kansas Flood of 1951**

C. H. CHORPENING, M. ASCE, Brig. Gen. U.S.A., Assistant Chief of Engineers for Civil Works, Washington, D.C.

11:00 **Construction of the Morganza Control Structure**

D. L. WHITE, M. ASCE, U.S. Army Corps of Engineers.

HYDRAULICS DIVISION

9:30 A.M. BEAUREGARD ROOM

Presiding: George R. Schneider, Member, Executive Committee, Hydraulics Division

9:30 **Vermillion River Basin of Southwestern Louisiana**

(a) **Surface-Water Resources and Sanitary Problems**

E. L. HENDRICKS, A.M. ASCE, Hydraulic Engineer, U.S. Geological Survey, Baton Rouge, La.

(b) **Ground-Water Resources and Salt Water Contamination Problem**

PAUL H. JONES, District Geologist, U.S. Geological Survey, Baton Rouge, La.

Discussion

C. K. OAKES, M. ASCE, Chief, Hydraulics Section, Louisiana State Department of Public Works, Baton Rouge, La.

WILLIAM F. GUYTON, A.M. ASCE, Consulting Engineer, Silver Spring, Md.

11:00 **Drainage in Louisiana—Authorized and Financed—Under Statewide Drainage Law**

BYRON P. LYONS, Chief Engineer, Louisiana State Department of Public Works, Baton Rouge, La.

Surveying and Mapping Division

9:30 A.M. JACKSON ROOM

Presiding: Henry B. Aikin, Member, Executive Committee, Surveying and Mapping Division

9:30 **Topographic Mapping in Louisiana**

GERALD FITZGERALD, Chief Topographic Engineer, U.S. Geological Survey, Washington, D.C.

10:00 **Surveying for Petroleum Operations in the Gulf of Mexico**

ROBERT L. SUGGS, Overseas Navigation Company, New Orleans, La.

10:30 **Photogrametric Mapping**

A. C. MILLER, M. ASCE, Vice President, Michael Baker, Jr., Inc., Jackson, Miss.

11:00 **Property Surveys in the City of New Orleans**

F. C. GANDOLFO, JR., Surveyor, New Orleans, La.

CONVENTION LUNCHEON

12:30 p.m. Friday, March 7

For Members and Guests

THE ST. CHARLES HOTEL

Tickets $3.00.

FRIDAY AFTERNOON, MARCH 7

Division Sessions

Construction Division

2:30 P.M. CLAIBORNE ROOM

Presiding: Ross White, Member, Executive Committee, Construction Division

2:30 **Offshore Petroleum Installations**
JACK S. TOLER, Humble Oil and Refining Co.

3:00 **Economics in Design and Construction of Petroleum Facilities in the Gulf of Mexico**
C. P. BESSE, Chief Engineer, California Oil Co.

3:30 **Major Pipeline Crossings of the Mississippi River**
P. H. TIMOTHY, Southern Natural Gas Co., and R. P. GREGORY, Houston Construction Co.

Hydraulics Division

2:30 P.M. BEAUREGARD ROOM

Presiding: George R. Schneider, Member, Executive Committee, Hydraulics Division

2:30 **Bridge and Culvert Waterways—Application of Hydraulics and Hydrology to the Design**
CARL F. OZZARD, Chief, Hydraulics Branch, U.S. Bureau of Public Roads, Washington, D.C.

Discussion
TATE DALRYMPLE, A.M. ASCE; Hydraulic Engineer, U.S. Geological Survey, Washington, D.C.

3:30 **Tranquil Flow Through Open-Channel Constrictions**
CARL E. KINDSVATER, A.M. ASCE; Professor, School of Civil Engineering, Georgia Institute of Technology
R. W. CARTER, J.M. ASCE; Area Engineer, Water Resources Division, Surface Waters Branch, U.S. Geological Survey, Atlanta, Ga.

4:15 **Hydrology of the New Orleans Area**
JOHN ALEE, Assistant Professor, College of Engineering, Tulane University, New Orleans, La.

CIVIL DEFENSE SESSION

2:30 P.M. JACKSON ROOM

A panel discussion led by outstanding authorities in the Civil Defense Administration will be presented under sponsorship of the ASCE Civil Defense Liaison and the Louisiana Local Section.

LADIES' ENTERTAINMENT

Ladies Headquarters
ROOM B, ST. CHARLES HOTEL

Wednesday, March 5

a.m. Coffee hour and reception during registration

12:30 p.m. Membership luncheon—Grand Ballroom, Roosevelt Hotel

p.m. Boat ride, *Good Neighbor*
Cocktail hour
Dinner-dance at the St. Charles Hotel Claiborne-Beauregard Rooms

Thursday, March 6

Noon Ladies luncheon at Orleans Club followed by tour of University section, Audubon Park and the garden district. Tickets $3.00. Transportation provided.

p.m. Boat ride on the Mississippi River steamer *President*

Friday, March 7

Noon Ladies luncheon and style show Blue Room—Roosevelt Hotel Tickets $3.00.

STUDENT CHAPTER CONFERENCE

Tuesday, March 4

CLAIBORNE ROOM, ST. CHARLES HOTEL

Student registration opens 8:30 a.m. Fee $1.00.

9:30 a.m. **Student papers**

12:30 p.m. **"Meet-the-Board" luncheon**
Jackson Room, St. Charles Hotel

2:30 p.m. **Forum on Chapter operations**

6:30 p.m. **"Get Acquainted" dinner at Arnaud's Restaurant**

Wednesday, March 5

2:00 p.m. **Tour of Union Terminal Project construction**

Throughout the days of the New Orleans Convention, students are cordially invited and encouraged to attend Technical Division sessions and any other Convention events.

STUDENT CHAPTER FACULTY ADVISERS' CONFERENCE

Friday, March 7

9:30 A.M. ROOM D, ST. CHARLES HOTEL

Faculty Advisers from ASCE Student Chapters throughout the southern part of the country will convene in the St. Charles on Friday of the Convention week.

This conference, which is primarily for invited advisers, will be open to all Contact Members of Chapters as well, and others interested in the activities and operational details of ASCE Student Chapters.

CLUB PRIVILEGES

Delegates desirous of enjoying the hospitality of the New Orleans Country Club or the Metairie Country Club are requested to make their wishes known to any of the local Convention Committee so that courtesy cards may be provided during their stay in the city.

NEW ORLEANS CONVENTION COMMITTEES

DAVID W. GODAT, *General Chairman*
LEE H. JOHNSON, *Vice-Chairman*

Executive Committee
DAVID W. GODAT — E. M. FREEMAN
FRANK W. MACDONALD — JOHN RIESS
BERNHARD M. DORNBLATT

Hotel and Registration
C. GLENNON MELVILLE, *Chairman*

Technical Program
BERNHARD M. DORNBLATT, *Chairman*

Entertainment
CHARLES M. KERR, *Chairman*

Student Activities
LEE H. JOHNSON, *Chairman*

Excursions
ALVIN FROMHERZ, *Chairman*

Reception
FRANK W. MACDONALD, *Chairman*

Publicity
J. M. LEDOUX, *Chairman*

Finance
JOHN RIESS, *Chairman*

Local Sections Cooperation
E. M. FREEMAN, *Chairman*

Transportation
T. EDWARD ERNST, *Chairman*

Women's Activities
MRS. FRANK W. MACDONALD, *Chairman*

Hotel Accommodations

Headquarters of the New Orleans Convention will be the St. Charles Hotel, located in the central business district of New Orleans, convenient to all facilities of the city. Special arrangements have been made to accommodate many Convention visitors at the headquarters hotel, up to capacity, in the order that reservation requests are received.

Send your reservation request early to assure space at the headquarters hotel. For your convenience a special request form is provided in the advertising section of this issue (page 135). Late requests may have to be assigned to other nearby hotels.

Information and Registration

Information and registration facilities will be maintained on the Convention floor of the St. Charles Hotel throughout the days of the Convention. Mail and messages will be held for members at the Information Desk.

SOCIETY NEWS

Centennial of Engineering, 1952

WILLIAM N. CAREY — E. L. CHANDLER

Executive Secretary ASCE and Assistant Secretary ASCE and Manager, Centennial Convocation, Respectively

The year 1952 will mark the centennial celebration of the 100th anniversary of the founding of the American Society of Civil Engineers, the oldest national engineering society in the United States. In 1852, engineering in America was divided into two branches, military and civil. We now have many specialized branches of engineering and many national societies of engineers but all are a part of the one-time civilian or "civil" engineering profession. As such, all have a mutual interest in celebrating the Centennial of Engineering in 1952.

The universality of this interest was quickly shown by enthusiastic cooperation among the societies of Engineers Joint Council. Council is composed of the principal national engineering societies representing the five basic branches of the profession. They are American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, the American Society of Mechanical Engineers, American Institute of Electrical Engineers and American Institute of Chemical Engineers. These five federated organizations have a combined membership of more than 130,000. The list of participants has expanded to nearly 50 national and international engineering organizations which now are supporting the objectives of the Centennial.

During the past century, the remarkable advancement of our country has been due in a considerable degree to the contributions made by American engineering and technology. The centennial celebration is an outstanding opportunity to commemorate the services of the engineering profession to the nation. It will bring to the people of the United States and the world a more complete understanding of some of the principal reasons why the United States has reached its present high stage of development.

Engineering and industry will use this opportunity to make the Centennial an occasion of national and international significance. To direct the overall phases of the celebration, a special not-for-profit corporation, Centennial of Engineering, 1952, Inc., has been created, with its headquarters at the Museum of Science and Industry in Chicago. Lenox R. Lohr, Member ASCE, president of the Museum, is president of the Corporation. Charles F. Kettering, Honorary Member ASCE, is chairman of the Executive Committee. Necessary money for financing the general features of the celebration is being raised by the Corporation through contributions from industrial and manufacturing organizations. It is contemplated that approximately $1,000,000 will be required.

There will be appropriate local and regional observances during the year throughout the United States, with the major activity in Chicago during the summer and early fall. The two principal functions in Chicago will be the Exposition with a dramatic presentation or pageant, and the Convocation, all centering around the Museum of Science and Industry. The museum now houses what is generally considered to be the world's finest collection of exhibits in the fields of science, engineering and industry. Those already on view to the public have cost many millions of dollars and are an admirable adjunct to the Centennial. Exhibits are dynamic. They are designed for educational benefit to those with technical and scientific understanding and to be interestingly informative and educational to the general public as well. Every year the museum has millions of visitors of all ages and walks of life, the total attendance last year having been about 3,000,000.

It is planned that new exhibits covering a wide scope of engineering will be installed in the museum to remain for several years. Special committees to advise on exhibits have been appointed in the major engineering societies and industries. The new exhibits, with those already housed in the museum, will form the exposition phase of the Centennial.

The Convocation is planned to be the greatest gathering of engineers ever assembled. It is scheduled to be held in Chicago during the period, September 3 to 13, 1952. Engineering societies of the United States and foreign countries will participate as will several international engineering organizations. Plans include a wide variety of technological activity. Symposium sessions are scheduled for each day throughout the Convocation period. The symposium subjects cover broad fields of engineering and industrial accomplishment. These presentations will be in language sufficiently non-technical to be understandable to the general public as well as to engineers.

In addition, individual societies will hold purely technical meetings. These will be similar to those customarily arranged by the societies for their regular conventions, but on a broader scale. Each such special session will be devoted to technical aspects of the particular field of engineering in which the sponsoring society or institute is identified. Joint technical sessions are being scheduled on subjects in which two or more societies have a mutuality of interest. Each participating society will arrange and finance its own meeting during the September 3 to 13 period. Financing of the general phases of the Convocation as well as the Exposition and Pageant is the responsibility of the Corporation.

The Convocation program will provide the opportunity of a lifetime for any engineer to reap the benefit of scholarly papers and discussions in his particular branch of the profession. He will be able also to profit from sessions devoted to other fields and techniques of engineering in which he may desire information.

The Department of State has expressed its intention to cooperate in encouraging attendance from foreign countries at the Centennial of Engineering. Officials of the Economic Cooperation Administration (ECA) have expressed keen interest in the program. The national engineering societies and institutions of Western Europe, Great Britain, Central and South America are all interested. Each will stimulate participation in the Centennial. Attendance by a large number of foreign engineers is assured. Engineers, domestic and foreign, will have available to them a veritable feast of engineering papers and scientific exhibits. The celebration also will carry an important message to the public.

This coming Centennial to celebrate "A Century of Engineered Progress" in the United States will have three major aims directed principally to the general public and to foreign visitors. The Centennial will be designed to make known the contributions of engineers to our national progress. It will depict clearly the role of industry, with its mass production and distribution, so essential to our high standard of living. Above all, it will attempt to demonstrate that an atmosphere of freedom and competition, with competent engineering and management in industry, is essential to maintain and increase the prosperity of the nation.

(The foregoing is printed at the request of the Board of Direction, from an Information Circular prepared at ASCE headquarters.)

Alfred Noble Prize Goes to Electrical Engineer

Eldo C. Koenig, an electrical engineer and member of the AIEE, has been awarded the Alfred Noble Prize for 1951 for a paper entitled, "An Electric Analogue Computer Using the Photo Cell as a Nonlinear Element." A joint award of the Four Founder Societies and the Western Society of Engineers, the Alfred Noble Prize consists of a cash award of $350 and a certificate.

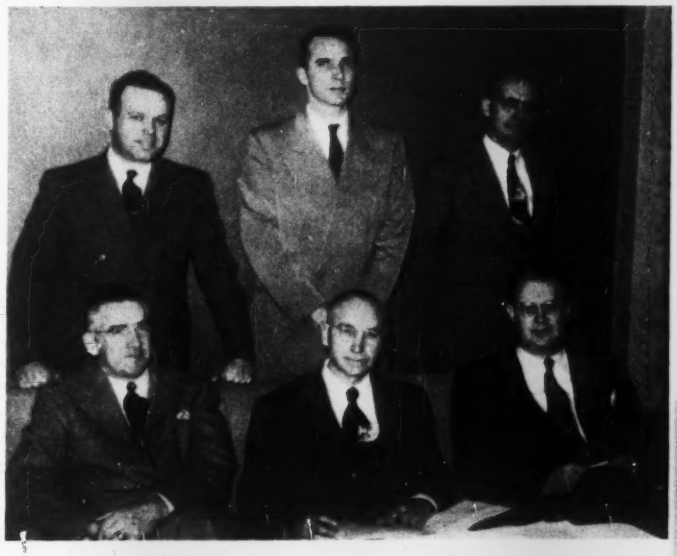
Eldo C. Koenig

A graduate of Washington University in 1943 with the bachelor of science degree in electrical engineering, Mr. Koenig joined the Allis-Chalmers Manufacturing Company after graduation as a test engineer at the Milwaukee plant on equipment for the Atomic Diffusion Plant. After the war he transferred to the motor-generator design section of the electrical department, where he is still employed.

He has also been enrolled in evening courses, receiving the master of science degree in electrical engineering from Illinois Institute of Technology in 1949 and the master of science degree in engineering from the University of Wisconsin in 1951.

Presentation of the prize will be made to Mr. Koenig at the winter general meeting of the AIEE in New York in January.

ASCE Committee on Student Chapters Meets



STUDENT CHAPTER PROBLEMS ARE DISCUSSED in recent two-day meeting in Chicago. Seated, left to right, are James M. Faircloth; D. M. Griffith, chairman; and G. Brooks Earnest, Board Contact Member. Standing, in same order, are Leo Novak, R. H. Dodds, and C. D. Williams.

Technical Program for Centennial Convocation Takes Form

Thirteen ASCE Technical Divisions have indicated their preliminary plans to participate in the Society's part in the Centennial Convocation in Chicago, during the period September 3-13, 1952. The Air Transport Division contemplates a presentation of the outstanding steps in the development of aviation, airports, aircraft, and airways with a peek into the future. The City Planning Division envisages a series of papers that will develop techniques of planning new towns, and guiding the expansion of big cities. Plans of the Construction Division include joint sessions with the Structural, Irrigation and Highway Divisions and with the Associated General Contractors, with separate sessions on the construction of pile foundations, caissons, and cofferdams; on the stabilization of soils; and on the mechanization of construction operations that has taken place during the past century.

Four sessions are planned by the new Engineering Mechanics Division to cover the mathematical method, structural and fluid dynamics, experimental analysis and analogs, and the mechanical properties of materials. In addition to its joint session with the Construction Division, the Highway Division plans sessions on design, construction, maintenance and administration of highways. Papers on several hydraulics subjects are planned by the Hydraulics Division.

Planning methods for irrigation projects in the United States will be compared with those in India and Australia in papers to be sponsored by the Irrigation Division. The place of the development and use of underground water for irrigation will be presented, and private and government development of irrigation projects contrasted. In the Power Division sessions papers are scheduled to cover the development of hydraulic prime movers, dams, multipurpose projects, and the status of atomic power. Progress during the past one hundred years in sanitary engineering, to be presented by the Sanitary Engineering Division, will include high-rate

G. Donald Kennedy

activated sludge treatment of sewage, sludge digestion, sedimentation tanks, garbage disposal, and air pollution, with a panel discussion of future needs in the field. Geophysical exploration, interpretation of soil conditions from aerial photographs, and geological and soil mechanics investigations will be covered by papers planned by the Soil Mechanics Division.

A program being arranged by the Structural Division contemplates coverage of riveted and bolted structural joints, and steel and timber structures. The Structural Division also plans a joint session with the Construction Division and the American Concrete Institute on prestressed, precast, and thin shell concrete structures, and another with the American Welding Society on welded steel structures. The Surveying and Mapping Division has scheduled papers covering the wide range of surveying methods required by engineers for both civil and military operations. Water transportation, navigation locks and dams, the development of hydraulic dredges, and the construction and operation of big Mississippi and Missouri River projects are scheduled for examination by the Waterways Division.

The Convocation in Chicago is to be the climax of the celebration during all of 1952, to mark a century of engineered progress, and to coincide with the Centennial of ASCE. Two score national and international engineering organizations are planning participation in the Convocation by holding meetings concurrently with ASCE's meeting during the convocation period in September 1952. It will bring together the world's outstanding engineers. In addition to the specialized technical meetings of the participating societies, subjects of general interest to non specialist and layman will be presented in non technical terms. Some of the subjects scheduled will bear on the contributions to the welfare of our nation made by advances in communication, construction, energy, food, mining, foods, and transportation. These meetings are to be open to every interested person.

ASCE's technical program for the Convocation is being developed by the Society's Technical Divisions, coordinated by G. Donald Kennedy, M. ASCE, of the Portland Cement Association, Chicago, who is chairman of the Society's Committee on Technical Program. Mr. Kennedy has the dual role of chairman of the Coordinating Committee on Technical Programs of participating societies.

Michigan Section Is Host to Executive Committee

A combination of the annual meeting of the Michigan Section and the ASCE Executive Committee was held in Detroit on December 13. In addition to providing excellent facilities for the work of the committee, the joint meeting gave Michigan Section members an opportunity to meet new Society officers.

Talks on a variety of topics of professional concern featured the annual meeting in the evening. Opportunities presented by the Centennial year for an aggressive campaign to mark the role of individual initiative in the creation and maintenance of a high standard of living were stressed by ASCE President Carlton S. Proctor in the principal address. Mr. Proctor also gave an idea of the scope of the Centennial Convocation program, which is expected to bring at least 20,000 engineers to Chicago during the period, September 3-13, 1952.

Daniel V. Terrell, Vice President for ASCE Zone III which includes the host Section, related the extent to which engineering unity exists in the successful operation of such joint organizations as Engineers Joint Council. Continued use of proved "unity" groups in carrying forward programs of concern to more than one specialty group is assured, Dean Terrell told the gathering. As an example of such unity at local level, Director Gordon H. Butler, of District 7, cited the operation of local engineering councils and joint groupings of the design professions in such specific matters as the establishment and improvement of registration provisions.

New Michigan Section officers elected during the annual meeting include Edwin A. Finney, of East Lansing, as president, and Prof. John C. Kohl, of Ann Arbor, as secretary-treasurer.

Centennial Chairmen Meet

An added feature of the Detroit program was a joint meeting of the coordinating chairmen of the Centennial celebration and the Executive Committee. G. Donald Kennedy, chairman of the Coordinating Committee on Technical Program, and Howard F. Peckworth, chairman of the Coordinating Committee on General Arrangements, reported plans made to date for the Chicago Convocation.

District 7 Council Reorganized

A revival of the District 7 Council of ASCE Local Sections was also celebrated during the Detroit program with a conference of officers from the Duluth, Michigan, Northwestern, and Wisconsin Sections. The objective of such organizations is to facilitate joint action on professional matters of interest to the several Sections.

Instrumental in the reorganization of the Council was Director Butler, who was assisted by Charles Yoder, chairman of the Committee on Local Sections. Mr. Yoder, who is also president of the Wisconsin Section, served as delegate of his Section to the Conference. Representing the host Section were Clyde Palmer, president; Dudley Newton, secretary-treasurer; Edwin Finney, president-elect; and Benson Wood, program chairman. Other delegates were Harry C. Walker, president of the Duluth Section; C. W. Britzius, president of the Northwestern Section; and R. E. Boech, secretary-treasurer of the Wisconsin Section. Vice President Terrell also attended the conference.

Reactivation of the group makes seven District and regional councils within the Society.

ASCE MEMBERS LIVING IN AUGUSTA-AIKEN AREA meet in Augusta to form Augusta Sub-Section of Georgia Section. Seated, left to right, are Ray Gauger, Sub-Section vice-president; Burton J. Bell, secretary-treasurer-elect for Georgia Section; Josef Patchen, Augusta, Sub-Section president; Moses E. Cox, 1951 president of Georgia Section; Curtis A. Nelson, project manager for Atomic Energy Commission, South Carolina project; and Warren S. Mann, Atlanta, president-elect of Georgia Section.

FROM THE NATION'S CAPITAL

JOSEPH H. EHLERS, M. ASCE — Field Representative ASCE

The critical materials situation continues to be the key to engineering and construction activity in the near and intermediate future.

Steel Applications to Be Screened

As mentioned in this column for November, applications for structural shapes for the fourth quarter totaled twice the amount available and were far in excess of the greatest amount ever shipped during any quarter year. Apparently this situation resulted from applicants requesting more steel than was needed for the quarter, partly because of the lack of any assurance from the government that material to complete an authorized structure would be forthcoming for the succeeding quarter.

The partial remedy that has been applied came, not from consultation with construction interests, but from the steel industry which is adequately represented on the government controls staff and whose advisory counsel is eagerly sought. A screening committee of five experts from the structural fabricating and erecting business, acting under the directorship of James B. Steep, consulting engineer of Detroit, will review all applications calling for more than 250 tons of structural steel to determine whether the needs have been realistically stated with reference to total quantity and to timing. This committee will serve as adviser on construction to the DPA Office of Program and Requirements. If this committee of top experts is permitted to regulate the timing for the delivery of shapes not only for private construction but also for military and other federal government construction, its chances for bringing the situation under control are good.

The construction industry had been led to believe reports that the shortage of shapes was not entirely real, but steel fabricating groups assure us that the demand as currently reported by claimant agencies is far in excess of the supply, and also that no significant gray market situation exists with respect to structural shapes. Hence the industry has probably underestimated the need for restrictions in the use of steel. The Construction Industry Advisory Committee to NPA has rarely been asked for advice by the government and has been kept poorly informed of the situation, although at the time the "stop construction" amendment to Order M-4 misfired last year, an assurance of cooperation with the industry committee was given.

Scrap Metal Collection Pushed

The situation will ease when the current steel and aluminum expansion programs no longer draw on the supply even though no new facilities for producing shapes are included in the expansion program. Steel men indicate that their worry will be to find a market for structural shapes in 1953. While 1952 will probably mark the end of the steel and aluminum shortages, copper may be scarce throughout 1953. Military uses take between 40 and 50 per cent of all copper supplies now, with total demand at more than 180 per cent of the supply. The metals situation for the next four months is bad—so bad that DPA is greatly intensifying its drive to stimulate scrap collection of steel, copper, and aluminum. At a recent meeting the DPA Administrator said that an imminent danger of shut down exists at a number of open-hearth plants. The recent order dealing with requisition of property urgently needed (DPA Reg. 3, Dec. 11) may have to be applied in the scrap situation if necessary to move the materials to the furnaces. Government agencies that heretofore have transferred aluminum, copper, zinc and lead scrap to the strategic stockpile will henceforth put it to immediate use, under a recent proclamation by the Secretary of Commerce. As a result of government effort, scrap metal is beginning to come in from Guam, Okinawa and the Pacific Islands. Another possible development may be a more drastic prohibition list for builders' hardware of copper and aluminum.

For the first quarter of 1952 allotments of structural steel amount to 370,000 tons out of a total of 610,000 tons requested for the industrial expansion program. Principal priority was given for aluminum, copper, electronics and aircraft producing facilities.

Substitute Materials Found

Although copper producers naturally resent attempts to shift to substitute materials, there appears reason to believe that substitutes must and can be found for such items as copper flashing, gutters and large size wire. With respect to aluminum wire certain technical difficulties, such as the loss of conductivity at junctions and splices due to surface oxidation, and electrolytic action where copper and aluminum come in contact with each other, have been overcome. For the larger wire sizes the lesser ductility of aluminum does not seriously mitigate against its use. The electrical contracting industry views the substitution for wire sizes larger than No. 6 as permanently acceptable. Incidentally, the Anaconda Company will build a 72,000 ton aluminum plant in Montana.

Conservation in Design Studied

Conservation is being studied from other angles than the substitution of one material for another. Building codes and design expedients offer a promising field for effecting savings. The Building Research Advisory Board has been reviewing the conservation problem under contract with DPA. One of the tentative conclusions is that there is a lack of ingenuity in design in the work done for and by certain governmental departments due to a lack of incentive offered. This comes as no surprise to those ASCE members who have been trying to combat the method of engaging and compensating for professional design services currently being used by certain government agencies (August issue, page 59) which have insisted that they did not require the highest grade engineering services but rather were buying blueprints for standard structures already evolved by them. Many owners have discovered that money skimped on engineering services is dissipated many times over in construction costs.

Construction Activity at Record Level

Construction is beginning to reflect the materials shortage and construction controls. Although new construction activity for the first eleven months of 1951 was over $27 billion and 8 percent higher than the corresponding 1950 figure, the increase was due to public construction

ASCE MEMBERSHIP AS OF DECEMBER 8, 1951

Members	7,979
Associate Members	10,166
Junior Members	15,566
Affiliates	66
Honorary Members	57
Fellows	1
Total	33,815
(December 8, 1950	31,069)

expenditures which were 29 percent ahead of 1950, reflecting enormous increases in military and naval and industrial plant expansion despite a slight decline in highway construction.

Electric power production facilities, direct military construction and industrial expansion will continue at a record pace in 1952. The electric power program involves a 40 percent increase of our capacity in three years. Construction funds available to the Department of Defense for obligation during fiscal year 1952 amount to $57 billion. During the 16 month period following the attack on Korea, the Department obligated $24 billion for construction.

ECA Liberalizes Professional Services Contracts

The Economic Cooperation Administration has recently issued a revised method of establishing fees for professional service contracts (PMCD Bulletin No. 35, revised). The original bulletin was issued during 1950 and had been the subject of some adverse comment from consulting engineers. The new regulation liberalizes the procedure. Requests for the bulletin or for answers to any question on it may be addressed to the Internal Audit Branch, Economic Cooperation Administration, Room 706, 734 15th Street, N.W., Washington 25, D.C.

According to General Salary Order No. 8, issued December 13 by the Salary Stabilization Board, salaried professional engineers may receive proportional extra compensation when working longer than a normal work week.

Washington, D.C.
December 17, 1951

Group Disability Plan Pays First Accidental Death Claim

Although the group disability insurance plan adopted by the Board of Direction over two years ago has made numerous payments to insured members suffering disabilities, the first accidental death claim has just been paid.

On August 1, 1951, the member (a civil engineer and highway construction contractor) was instantly killed when his car struck a concrete bridge. Initial notice of the insurance claim was received in the home office of the Continental Casualty Company, underwriters for the group plan, on August 31, and a draft for $5,000 was forwarded to the widow and beneficiary on September 11.

Daniel W. Mead Prizes Awarded for Essays on Ethics

This year's winners of the Daniel W. Mead Prizes for the best essays on a subject involving professional ethics are two veterans Edgar G. Baugh, Jun. M. ASCE, winner in the Junior category, and Marion K. Harris, who receives the Student Chapter award for a paper written while he was a member of the Society's Student Chapter at the University of California. Both wrote on the subject, "Why Is a Code of Professional Ethics Desirable?"

In World War II, Mr. Baugh was in the Infantry for a year and the Air Force for four years. He was commissioned a captain in meteorology, serving as B-17 navigator with the Eighth Air Force in the European Theater. Upon his return to the United States, he studied civil engineering at the University of Nebraska and Georgia Institute of Technology, where he was vice-president of the Society's Student Chapter and editor of *The Georgia Tech Engineer*. Since his graduation from Georgia Tech in June 1949, he has been employed by the Humble Oil and Refining Co., and is now associate engineer in the Production Department of the company's Gulf Coast Division, with headquarters at Houston, Tex. Mr. Baugh will receive his award at the Society's Spring Convention in New Orleans.

In 1944, after four years with the post engineer at Benicia Arsenal, Mr. Harris entered the U.S. Navy, serving for almost two years as a radio technician. He then studied electrical and civil engineering at the University of California, graduating with the B.S. degree in civil engineering in June 1951. Mr. Harris received his award at the annual meeting of the San Francisco Section in December.

Edgar G. Baugh

Marion K. Harris

News of Local Sections Briefed

SECTION	DATE	ATTENDANCE	PROGRAM
Alabama	December 7-8		Annual winter meeting. Speakers on technical program included James W. Morgan, commissioner of public improvements for Birmingham, Ala.; ASCE Director Edmund Friedman; E. G. Koelliker, sales engineer, General Electric Co., at Birmingham; W. N. Woodbury, consulting engineer of Birmingham; C. L. Cookson, with J. B. Converse & Co., Inc., at Mobile; W. F. Beldon, supervisor, process service, Linde Air Products Co., at Birmingham; and R. Landberg, with U.S. Pipe & Foundry Co., at North Birmingham. Banquet featured an address by Warren Whitney, vice-president, James B. Clow & Sons, at Tarrant, and presentation of Life Membership certificates. Election of officers.
Arizona	November 24		Annual meeting. Field trip to Allison Steel Manufacturing Co. John C. Park, dean, College of Engineering, University of Arizona, spoke on "The Status of Engineering Education" and "Engineering an Opportunity" at morning session and joint luncheon with American Association of Engineers. At afternoon session W. A. Steenbergen, chief of Operations Division, Lower Colorado River District, U.S.B.R., at Yuma, discussed progress on development of the Wellton-Mohawk

PENNSYLVANIA TURNPIKE EXTENSION

Topographic survey for 140-mile highway. Ground methods estimate: $415,000 and 2½ years. AERO delivered completed maps 145 days after start for $83,000.

Saving—$332,000 and 769 days.

BEAR MOUNTAIN HIGHWAY LINK

Topographic survey for 31-mile New York highway. Ground methods estimate: $74,400 and 2 years. AERO delivered maps in 90 days, for $17,500.

Saving—$56,800 and 640 days.

210,000-ACRE AEC FACILITY

Topographic survey for huge new Atomic Energy facility in S. Carolina. Maps for 210,000 acres were delivered 160 days after start.

Saving—years faster than ground surveys.

CITY MAPPING FOR DURHAM, N.C.

Topographic survey of 31-sq. mile city area. AERO mapped in 7 months for $30,000. Ground methods estimate: costs $180,000 and over 5 years.

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Coming Local Section Events

Buffalo Meeting at the Buffalo Athletic Club, January 15, at 12:15 p.m.

Cleveland Dinner meeting at the Carter Hotel, Cleveland, January 11, at 7 p.m.

Colorado Meeting at the Democratic Club, Denver, January 14, at 6:30 p.m.

Kansas City Meeting at the Wishbone Restaurant, Kansas City, Mo., January 16.

Los Angeles Dinner meeting of Soils Mechanics Group at the Hotel Clark, Los Angeles, January 16, at 6:30 p.m. Meeting of Sanitary Group at the Hotel Clark, January 23, at 6:30 p.m. Field trip to Pershing Square Garage Project on January 26, at 10 a.m. Weekly Junior Forum luncheons every Friday at the Globe Restaurant, Los Angeles, at 12 noon.

Louisiana Joint meeting with Louisiana Engineering Society in New Orleans, January 10-12. Annual meeting in New Orleans, January 26.

Maryland Meeting at the Engineers Club of Baltimore, January 9, at 8 p.m., preceded by cocktails at 6 p.m. and dinner at 7 p.m.

Metropolitan Meeting in the Engineering Societies Building, New York City, on January 16, at 8 p.m. Meeting of Junior Branch in the ASCE Board Room, New York City, on January 9 and 23.

Mid-South Dinner meeting of Jackson Branch of Section at the Hotel Heidelberg, Jackson, January 31, at 7 p.m.

Northwestern Dinner meeting in the Junior Ballroom of Coffman Memorial Union, University of Minnesota, Minneapolis, on February 4.

Pittsburgh Annual meeting at the Hotel William Penn on January 29.

Sacramento Weekly luncheons every Tuesday at the Elks Temple, Sacramento, at 12 noon.

San Diego Meeting in San Diego on January 22.

South Carolina Annual winter meeting at the Columbia Hotel, Columbia, S. C., on January 25.

Tennessee Valley Meeting of the Muscle Shoals Sub-Section on January 17, 6:30 p.m.

Scheduled ASCE Conventions

NEW ORLEANS CONVENTION
St. Charles Hotel
New Orleans, La., March 5-7, 1952

DENVER CONVENTION
Cosmopolitan Hotel
Denver, Colo., June 16-20, 1952

CENTENNIAL CONVOCATION
Conrad Hilton Hotel
Chicago, Ill., September 3-13, 1952

OFFICERS AND GROUP OF IOWA STATE COLLEGE STUDENT CHAPTER MEMBERS meet at Ames with Executive Secretary William N. Carey on November 14. Seated in second row, left to right, are Robert Fenelon, Student Chapter secretary; Tom Markel, vice-president; W. C. Alsmeyer, Faculty Adviser; Secretary Carey; Prof. L. O. Stewart, secretary of Iowa Section; Max Ferguson, Student Chapter president; John Pizzato, secretary; and Don Hattery.

			Division of Gila Project; Charles Pillar, with San Manuel Copper Corp., at Superior, and Magma Copper Co., at Tiger, spoke on the San Manuel Project; S. H. Taylor, regional manager, Lincoln Electric Co., at Emeryville, Calif., described structural welding; and J. E. Hastian, Phoenix consultant, talked on "Field Welded Structural Frames, a Transitional Change in Design and Construction."
Central Illinois	November 6	40	Dinner meeting. Daniel Kennedy, central region engineer, Topographic Branch, U.S. Geological Survey, was speaker of evening.
	December 4		Annual meeting with election of W. Leighton Collins, as president; Carl M. Wahl, first vice-president; William A. Oliver, second vice-president; and Clyde E. Kesler, secretary-treasurer. Discussion of Centennial of Engineering.
District of Columbia	November 13	93	Annual meeting. ASCE Director Frank L. Weaver reported on Society's Annual Meeting. Election of Section officers. Presentation of Life Membership Certificates. Section Student Awards went to Elijah Brewer, student of Howard University; Edward R. Campbell, George Washington University, and Charles I. Supplee, Catholic University (first Section award to student at C.U.)
Intermountain	November 15	104	Joint dinner meeting with Utah Engineering Council. Roger F. Waindle, vice-president of the American Society of Tool Engineers, spoke on "Production in Peace and War." ASCE Director Milton T. Wilson discussed Centennial of Engineering.
	November 16	27	Annual joint dinner meeting with Ogden Engineers Club. F. W. Smith and A. C. Spann, district engineer and engineer, Public Roads Administration, described organization's financing program and the proposed expressway for Salt Lake City.
Ithaca	October 30		Newly elected officers include G. E. Rickard, president; Prof. H. T. Jenkins, first vice-president; J. A. Norris, second vice-president; and Prof. J. C. Gebhard, secretary-treasurer.
Lehigh Valley	November 13		A film entitled, "Building for the Nations," was presented by United States Steel.

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Los Angeles	December 12		Election of Roy L. Anderson, as president; John Q. Jewett and George E. Brandow, vice-presidents; L. LeRoy Crandall, secretary; and John C. Merrell, Jr., treasurer. Junior Forum officers are President Jack B. Howe, Vice-President William J. Carroll, and Secretary Richard C. Gerke.
Maine	November 3		Joint meeting with Maine Association of Engineers. Afternoon session speakers were James L. MacLeod, city engineer, Bangor, Me.; Charles A. Whitten, bridge construction engineer, Maine State Highway Commission; and Ober C. Vaughan, director, State Personnel Board. Allen P. Richmond, Jr., Assistant to the Secretary, ASCE, New York, N. Y., was speaker of evening.
Maryland	November 15	105	Dinner meeting. Col. J. H. Sands, Jr., director of aircraft, Air Research and Development Command, U.S.A.F., pointed out the necessity for continuing research and development of new weapons and defenses.
	December 12	134	Dinner meeting with Dr. Ferdinand Hamburger, Jr., professor of electrical engineering at Johns Hopkins University, lecturing on radio, television, and radar.
Miami	November 1	20	Dinner and business meeting. Benjamin Atkins, of American World Airlines, talked on "International Air Cargo."
Mid-Missouri	November 1	95	Joint meeting with University of Missouri Student Chapter. Rex Whitton, chief engineer for Missouri State Highway Department, reviewed early history of highway department.
Mid-South	December 6-8		Annual meeting with 34 delegates from local Student Chapters. Newly elected officers include Kenneth W. Lefever, president; Lawrence A. Tvedt, vice-president; and W. G. Shockley, secretary-treasurer. H. I. Berg, senior highway engineer, Bureau of Public Roads, Fort Worth, Tex.; Silvio Spigolon, University of Mississippi; R. L. Davis, Mississippi State College; Messrs. J. F. Andrews and D. J. Rudig, University of Arkansas; Gen. Eugene Reybold, executive vice-president, American Road Builders' Association; Walter F. Winters, chief engineer, Asphalt Institute; and Col. L. W. Prentiss, division engineer, Southwestern Division, Corps of Engineers, were speakers.
Mohawk-Hudson	November 17	200	Symposium on prestressed concrete with Bertram D. Tallamy, state superintendent of public works, Albany, N. Y., acting as chairman. Participants included J. S. Kinney, professor of structural engineering at Rensselaer Polytechnic Institute; F. S. Merritt, associate editor of *Engineering News-Record*; J. N. Hicks, business manager for J. A. Roebling's Sons Co.; Nils Thorsen, engineer for Freyssinet Co.; J. T. Parrett, research engineer for Raymond Concrete Pile Co.; and John J. Hogan, structural engineer for Portland Cement Association. Section officers are Prof. H. G. Harlow, president; Paul Davis, vice-president; C. W. Davies, secretary; and Holbert W. Fear, treasurer.
Nebraska	October 19	62	Annual joint dinner meeting with University of Nebraska Student Chapter. Hal Hale, executive secretary, American Association of State Highway Officials, spoke on American highways.
	December 11		Annual meeting. Newly elected officers are J. O. Ackerman, president; D. D. Lewis, first vice-president; and G. R. Bathe, second vice-president.
New Mexico	December 7		Annual meeting with Tate Dalrymple, hydraulic engineer for U.S. Geological Survey, Washington, D.C., speaking on "How Stream Flow Records Help in Design of Bridge Waterways." Election of J. L. Cheatham, as president; R. W. Fife, first vice-president; W. G. Koulas, second vice-president; and L. A. Wheeler, secretary-treasurer.
Northeastern	November 26		Dinner meeting featuring Norris D. Hoyt of St. George's School, Newport, R. I., as speaker.

WILLIAM E. HAWLEY (right) receives certificate of life membership in ASCE from Gordon H. Butler, ASCE Director for District 7, at recent Duluth Section meeting. Mr. Hawley retired in 1951 after 35 years in engineering department of Duluth, Missabe and Iron Range Railroad. He is a University of California graduate and former secretary and vice-president of Duluth Section.

DEAN DANIEL V. TERRELL (left), ASCE Vice-President for Zone II, presents life membership certificates to veteran members Charles H. Blackman, retired chief engineer of Louisville & Nashville Railroad, and Prof. Wylie B. Wendt, of Speed Scientific School, at annual business meeting of Kentucky Section on December 7. Program also included address by Dr. Philip G. Davidson, new president of University of Louisville, and election of 1952 officers. Slate consists of Charles W. Lovell, president; Lowell E. Gregg, vice-president; John H. Clark, III, secretary-treasurer; and Clyde K. Warner, Jr., corresponding secretary.

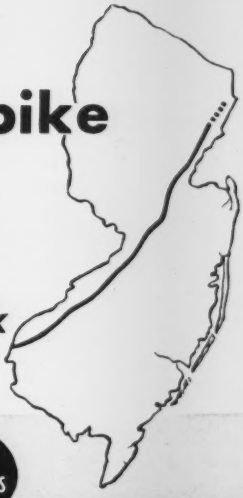
Set of "Transactions" Wanted

Edmundo Curiel, M. ASCE and president of the Venezuelan Institute of Sanitary Works, would like to obtain a complete set of bound copies of ASCE TRANSACTIONS, beginning with Volume I published in 1867. Members wishing to sell their collections should get in touch with Herman W. Zanino, Venezuelan Institute of Sanitary Works, 250 West 57th Street, New York 19, N. Y.

On the New Jersey Turnpike

...MONOTUBES

for simplified, speedy foundation work



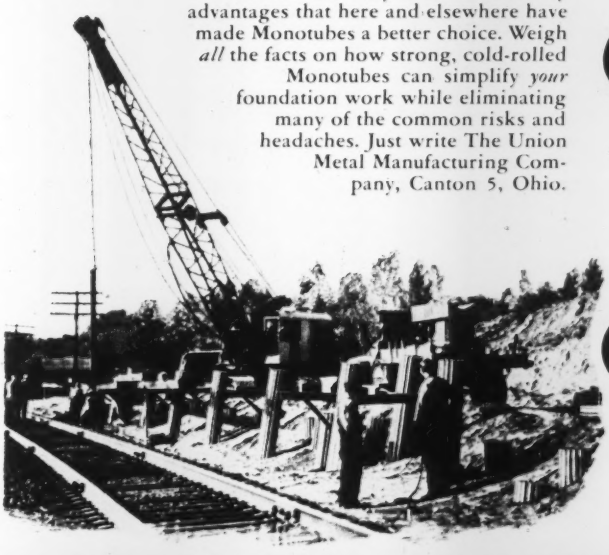
THESE and many other overpasses play a vital part in making the New Jersey Turnpike a "Miracle Highway". And, versatile Monotube piles went into *all* types of overpass construction—because they offer unique advantages.

For example, speedy construction was possible with light weight Monotubes, installed with fast, mobile driving equipment. There was minimum time loss in moving between the widely separated structures. *On* the job, Monotubes saved still more time and money due to their ready extendibility, simplified field splicing, easy cut-off and minimum waste . . . and, due again to their light weight that speeded locating and driving to any required depth.

These are only a few of the key advantages that here and elsewhere have made Monotubes a better choice. Weigh *all* the facts on how strong, cold-rolled Monotubes can simplify *your* foundation work while eliminating many of the common risks and headaches. Just write The Union Metal Manufacturing Company, Canton 5, Ohio.

OVER RAILROADS

OVER WATER



OVER HIGHWAYS

UNION METAL

Monotube Foundation Piles

NEWS BRIEFS . . .

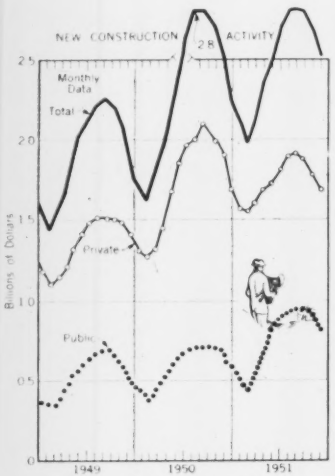
Further Decline in Construction Is Reported

A seasonal decline of 7 percent in construction activity in November, to $2.5 billion, is noted in a joint report of the Building Materials Division of the Department of Commerce and the Labor Department's Bureau of Labor Statistics. Although all major types of construction shared in the decline, public construction dropped off relatively more than private, chiefly as a result of the regular fall decline in highway work.

There were less than seasonal declines in residential building, privately owned public utilities, and important segments of public work, particularly in military and naval activity. However, both private industrial building and commercial building were off more than seasonally, reflecting materials shortages. Compared with the situation a year ago, expenditures for new construction put in place were down this November in almost all categories, with the principal exception of defense-connected work, such as industrial, military and naval, public utility, and hospital projects.

Despite the November decline in construction activity, the joint agencies report that total new construction activity from January through November of this year registered a gain of 8 percent compared with the 1950 level.

Private construction expenditures for the eleven month period amounted to $19.2 billion, only a slight increase above the 1950 volume for the same months. Outlays for new dwelling units and for social and recreational building were down substantially, but nearly all other types of private construction showed marked gains over the year, with industrial plant expenditures almost doubled. Public expenditures for the January-November period, at $8.5 billion, were 29 percent above 1950 outlays. The most significant increases were in construction of military and naval facilities, industrial building and schools. Highway construction was slightly under last year's levels.



SEASONAL DROP OF 7 PERCENT in construction activity in November is shown graphically in Department of Commerce curves.

Science Foundation Allotment Permits Start of Program

The $3,500,000 appropriation for the National Science Foundation in the Supplementary Appropriation Act of 1952, recently signed by the President, will permit immediate start of two major programs of the Foundation: support of basic research in the sciences and training of scientific manpower. A reduction in the appropriation from the President's budget request of $14,000,000 for the 1952 fiscal year has necessitated material adjustment of the program originally presented to Congress.

According to Dr. Alan T. Waterman, director of the Foundation, approximately $1,500,000 of the available funds will be allocated for the support of basic research in biology, medicine, mathematics, the physical sciences, and engineering; about $1,350,000 for the training of scientific manpower; and the remainder for development of a national policy for the promotion of basic research and education in the sciences, for the wider dissemination of scientific information, and for other services, including support of the National Scientific Register, now established in the Office of Education.

Basic scientific research will in most cases be supported by means of research grants. No grants have been made to date, although a considerable number of research proposals have been received from investigators in all parts of the country. Following preliminary evaluation and review by the Foundation's three research divisions, the grants must be approved by the Director and the 24-member National Science Board. Chairman of the Board is Dr. James B. Conant, president of Harvard University.

The National Science Foundation Graduate Fellowship program will be directed by the Division of Scientific Personnel and Education, under Dr. Harry C. Kelly. Selection of fellows will be made solely on the basis of ability and will be carried on by the National Research Council. Applications will be considered from students in the natural sciences who have or will have completed their undergraduate work in any accredited college or university. Inquiries and applications should be addressed to the Fellowship Office, National Research Council, Washington 25, D.C.

Large Cement Plant Goes Into Production

Cement supplies for the Southern market will be increased by a new plant of the Marquette Cement Manufacturing Company that has just gone into production at Brandon, Miss. The first cement plant to be built in the state, the new unit will ship all types of portland and masonry cement to markets in Mississippi, Louisiana, and southeastern Arkansas. With a 450-ft kiln and present annual production rate of 1,000,000 bbl, the plant is designed to permit future expansion. Construction was started about a year ago.

Mechanical Engineers Elect 1952 Officers

Reginald J. S. Pigott, director of the engineering division of the Gulf Research and Development Co., of Pittsburgh, a subsidiary of Gulf Oil Corp., was elected president of the American Society of Mechanical Engineers at the society's recent 72nd annual meeting in Atlantic City.

Regional vice-presidents elected were Willis F. Thompson, chief mechanical engineer, Westcott & Mapes, Inc., New Haven, Conn.; Ernest H. Hanhart, consulting mechanical engineer, Baltimore, Md.; Ernest S. Theiss, assistant chief engineer, Davey Compressor Co., Kent, Ohio; and Samuel H. Graf, director, Engineering Experiment Station, Corvallis, Oreg. Elected directors-at-large were Albert C. Pasini, superintendent, production department, the Detroit Edison Co., Detroit, Mich., and Paul B. Eaton, head, mechanical engineering department, Lafayette College, Easton, Pa.

Large Volume of Defense Work Slated for Alaska

A "Prospectus of Construction," to be accomplished in the Alaskan Command during 1952–1953, has been issued by the Alaska District of the Corps of Engineers. Listing some 96 new jobs with an estimated cost of about $170,000,000, the prospectus states that new projects will be awarded on the basis of open competitive bidding and that the formal Notice to Prospective Bidders detailing proposals and requirements as scheduled will be made available to firms requesting it.

At present defense construction work in Alaska supervised by the Army Corps of Engineers is proceeding on 114 contracts that were let during 1951 at a total cost of $190,000,000. Types of construction under the current program range from Alaska's largest building—a composite six-story Army center at the Port of Whittier—to reinforced concrete barracks and service buildings and frame quarters for families. Projects currently under contract for construction, design, and services total about $250,000,000.

The forthcoming construction program includes vehicle repair shops, gasoline stations, administration buildings, warm storage units, Post Engineer facilities, telephone exchanges, indoor training facilities, refrigerated warehouses, maintenance shops, a bakery, port facilities, a laundry and dry cleaning plant, ammunition storage, a hospital, water and sewage treatment plants, theaters, ordnance and artillery shops, an Arctic training school, commissaries, a locomotive shop, a cold storage plant, barracks, bachelor quarters, family housing, central power and heating plants, bulk liquid fuel systems, utilities (including water, sewer, steam and electric lines), communication systems, fire stations, and many other projects.

The "Prospectus of Construction" and other details are available from the Technical Information Office, Alaska District Engineer, Anchorage, Alaska.

Preserve Your Periodicals

Arrangements have been made with the Library Binding Institute, an organization representing a number of library binderies specializing in binding serial publications into volumes, to give members assistance in binding their periodicals. This binding may be done in accordance with the American Library Association's "Minimum Specifications for Class 'A' Library Binding," a standard for volume binding.

A request addressed to the Library Binding Institute, 501 Fifth Avenue, New York 17, N. Y., will bring members the names and addresses of certified binderies in their area, qualified to do binding in accordance with these specifications, together with instructions for preparing periodicals for Class "A" binding.

Heavy Equipment Speeds Idaho Power Dam Project

CONTROL GATES FOR SPILLWAY of C. J. Strike Power Dam at Grandview, Idaho, are assembled by contractor on project, Morrison-Knudsen Co., Inc., Boise, Idaho, by means of 20-ton Lorain Moto-Crane, Model MC414, equipped with 50-ft boom. This $18,500,000 dam on Snake River is one of five being built for Idaho Power Co. as part of intercommunicating electrical system serving southern Idaho and eastern Oregon. Of earthfill construction with rock surface, dam is 3,000 ft long and 120 ft high. It will be completed in 1952 and will have power output of 82,500 kw.

New York Bus Terminal Completes First Year of Operation

GOOD FINANCIAL showing is made by Port of New York Authority's $24,000,000 bus terminal, which completed its first year of operation in December. Total revenues for first year, amounting to about $1,600,000, are derived from 17 suburban and 13 long-distance bus lines and from rentable space, now 90 percent occupied. Connected to Lincoln Tunnel and New Jersey by overhead ramps, terminal has already improved midtown Manhattan traffic conditions. View shows roof-parking facilities for commuters' cars.

Huge Steam Plant to Power AEC Paducah Project

CONSTRUCTION IS PUSHED on Tennessee Valley Authority's $88,000,000 Shawnee Steam Plant near Paducah, Ky. With projected capacity of 1,500,000 kw, huge plant will furnish 50 percent of power required for new $500,000,000 Uranium-235 plant under construction by Atomic Energy Commission at Paducah. First of ten 150,000-kw units will be installed in December 1952, followed by other nine at six-week intervals. Excavation of powerhouse site, shown in photo, required removal of 469,000 cu yd of earth, which was accomplished by Caterpillar D8 Tractors and Scrapers, and Euclid bottom-dump trucks loaded by Koehring Shovels and Manitowoc Cranes. Some 24,100 cu yd of concrete went into powerhouse substructure. Construction now centers around completion of powerhouse, building intake structure, and excavation and dredging of intake and discharge channels. TVA carried out excavation of powerhouse area, and excavation and dredging of intake and discharge channels is under contract to Leuhr Brothers Construction Co., Columbus, Ky. Contract for building four 250-ft-high stacks is held by Custodis Construction Co., Chicago and New York.

Engineers' Panel Favors Hudson River as Source of Additional Water for New York

Use of the Hudson River as the next major source of water supply for New York City is recommended by the special panel of engineering experts appointed by the city in May 1950 to make both immediate and long range plans for expansion of the city's water supply system. The panel consists of Thorndike Saville, M. ASCE, dean, college of engineering, New York University, chairman; W. W. Horner, Past President ASCE and consulting engineer of St. Louis; Louis R. Howson, Director ASCE and consulting engineer of Chicago; and Abel Wolman, M. ASCE, professor of sanitary engineering, Johns Hopkins University.

In an 80-page report just made available by the Mayor's Committee on Management Survey, the engineering panel states that use of the Hudson to supplement existing sources would be preferable to the proposed Cannonsville development of upstate areas drained by the West Branch of the Delaware River. Simultaneously a report of the New York Board of Water Supply criticizing the recommendations of the engineering group and urging their rejection was also made public by the committee.

Arguments for use of the Hudson as a source of water supply contend that, with modern methods of filtration, the river will afford an adequate supply at lower cost than could be obtained elsewhere; the Hudson can be developed without time-consuming court action and interstate conflicts; the Hudson project could be operated more flexibly to conform with future requirements; in case of atomic bomb attack the Hudson supply would be safer as well as more easily decontaminated; and operating costs would be lower.

Advantages of the Cannonsville Project advanced by the Board of Water Supply include lower costs in the long run, with annual costs estimated at only $422,000 after the year 2000; better quality of upland supplies; and automatic operation of the Cannonsville project by gravity flow, in contrast to pumping and maintenance problems involved in operation of a Hudson River supply. An additional drawback to use of a Hudson River supply, cited by the Board of Water Supply, is that operating charges would have to be met from the city budget, whereas the Cannonsville project would be financed by borrowing outside the city's debt limit.

The engineering panel recommended that the Hudson be tapped at an intake just south of Hyde Park, and pumped through a tunnel to connect with the existing Delaware Aqueduct. Before mixing with present upland water supplies, the water would pass through a filtration plant. The estimated construction cost of this project, which would provide 325 mgd, is $39,185,000. An economic analysis by the staff of the mayor's committee, however, estimates the "true cost" of the Hudson project at $139,727,000 and that of the Cannonsville Project at $156,347,000. The estimate was based upon a 40-year bond issue.

As a more immediate solution to the city's water problem, the engineering panel urged that the city set up an organization to prevent water wastage from leaks and inadequate fixtures. It also recommended establishment of a metering system.

AASHO Drafts Statement of National Policy

Administrative officers of the American Association of State Highway Officials met in Chicago on November 27 to draft a national policy statement regarding new federal-aid legislation for highways. The policy statement will be submitted to the Congress convening in January 1952.

Recommendations include four authorizations for regular federal-aid funds totaling $810,000,000, to be apportioned on an annual basis as follows: Interstate highways, $210,000,000; primary, $270,000,000; secondary, $180,000,000; and urban $150,000,000. Distribution of primary, secondary, and urban allocations in accordance with the regular formulas and matching basis as provided in the Federal-aid Highway Acts of 1944, 1948, and 1950 was recommended. For the interstate funds, apportionment on the basis of the population of the states was suggested, with the stipulation that no state receive less than three-quarters of 1 percent.

Other annual authorizations requested include $32,000,000 for forest highways; $28,000,000 for forest development roads and trails; $16,000,000 for construction and maintenance of roads and trails, including necessary bridges, in areas administered by the National Park Service; $17,000,000 for construction and maintenance of access roads to national parks or connecting sections of national parkways; $10,000,000 for construction and maintenance of Indian lands and reservations; and $5,000,000 for roads on unappropriated federal lands. Another recommendation urged authorization of emergency relief funds for national disaster.

Navy Seabees Celebrate Their Tenth Anniversary

The Navy Construction Battalions (Seabees), master builders of World War II, celebrated their tenth anniversary on December 28 with stepped-up construction work at more than 30 naval bases and stations in various parts of the world. These projects include building of airstrips, roads, piers, utilities, and ammunition and fuel storage depots needed to give overseas support to the fleet and its air arm. The Seabees are also renovating many of the structures that supported the Navy's drive across the Pacific in World War II.

In recognition of their wartime record, the Seabees were made a permanent part of the Navy in 1946. At the same time, the Navy authorized a Seabee Reserve organization, which became an important source of Navy construction personnel when fighting began in Korea. To fill the ranks depleted by the calling of reservists to active duty, the Navy is still seeking men for the Seabee Reserve. The principal need is for older, skilled workers.

Modifications in the organization and designation of all but two of the old Naval Construction Battalions have been made during the past two years. The new organization provides for Amphibious Construction Battalions; Mobile Construction Battalions; Construction Battalion Maintenance Units; and Construction Battalion Detachments (small units trained for special duty). Stepped-up training programs are under way at Port Hueneme, Calif., and Davisville, R. I.

Florida Conference Studies Surveying, Mapping Problems

Latest developments in surveying and mapping, with particular attention to the activities of the surveying and mapping agencies working in Florida were featured in technical sessions comprising the recent Fourth Annual Surveying and Mapping Conference sponsored by the Civil Engineering Department of the University of Florida.

The overall situation was discussed by Carl I. Aslakson, M. ASCE, Comdr., U.S. Coast and Geodetic Survey, Washington, D.C.; Emil Van Brunt, U.S. Geological Survey; and William C. Cude, Engineer Research and Development Laboratories, Fort Belvoir, Va. Local activities in the field were reviewed by Earle J. Fennell, Assoc. M. ASCE, U.S. Geological Survey, Washington, D.C.; Wesley Seay, Florida State Road Department; Arthur L. Wardwell, Comdr., U.S. Coast and Geodetic Survey, Tampa, Fla.; and K. M. Hartsfield, Corps of Engineers, Jacksonville.

A. N. Winsor, assistant professor of civil engineering at the University of Florida, gave an illustrated lecture on "Determination of True Meridian by Observation on Polaris," and Jon Beazley, Jun. M. ASCE, of the Florida State Road Department, presented an actual demonstration of the steps involved in compiling a planimetric map from aerial photographs. The final topic was an open discussion on land surveying problems conducted by H. O. Peters, civil engineer of Leesburg.

The two-day session was attended by 200.

ASEE Solicits Aids for Engineering Teaching

The American Society for Engineering Education is issuing a call to industry, the professional societies, public and private research organizations, and the engineering colleges for teaching aids that may be reviewed in its forthcoming "Catalog of Teaching Aids." The proposed catalog, which is being prepared by ASEE through its Committee on Teaching Aids, will cover all kinds of devices helpful to the teaching of engineering subjects. The first edition will be limited to civil, electrical, and mechanical engineering, mathematics, and engineering mechanics, and to motion picture films (both sound and silent), slides (2 by 2 in. or 3¼ by 4 in.), models, charts and exhibits.

Information on such aids should be sent to Prof. Carl W. Muhlenbruch, chairman of the ASEE Committee on Teaching Aids, Northwestern Technological Institute, Evanston, Ill., who will see that they reach the proper reviewing group. Each offer of a teaching aid should be accompanied by a written description or photograph and a set of operation instructions.

Philippine Government to Build Veterans' Hospital

Construction of a $9,000,000 Filipino veterans' hospital, the largest and most modern in the Far East, will get under way in January, according to an announcement from the Philippine Association. The revised plans for the new hospital, which is being financed by the United States, have been turned over to the Philippine government by Brig. Gen. Ralph B. Lovett, Philippines manager of the U. S. Veterans Administration.

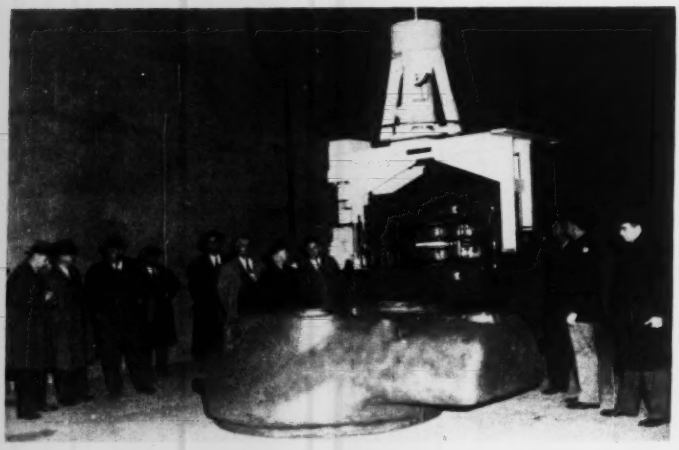
To be located on a 135-acre tract in Quezon City on Luzon Island, the project will include 27 separate buildings, its own water supply and sewage disposal systems and other facilities needed for servicing. A factory for the manufacture of artificial limbs, the first in the Philippines, is also planned.

Construction of the hospital, including the release of bids, will be directed by the Philippine government under supervision of the U.S. Veterans Administration in the Philippines. About two years will be required for construction.

New Construction Expands Kure Beach Corrosion-Testing Program

NEW FACILITIES FOR STUDY OF SEA WATER CORROSION are being added to Harbor Island Station of Kure Beach Project near Wilmington, N.C. These include laboratory building; full-size water evaporator and distillation units to study effects of water treatment and design on corrosion and scaling of such units, especially as used on board ship; additional facilities for laboratory study of marine organisms; and new test lot for exposure of specimens to sea spray. Operated by Corrosion Engineering Section of International Nickel Company, Inc., Kure Beach station has studied many thousands of specimens for other companies and government agencies in sea water, sea atmosphere, and sea spray in its 16 years of existence. Specimens studied include metals, wood, rope, and protective coatings.

Army Engineers Complete Betatron Plant



NEW CONCRETE BUILDING with walls 6 ft thick, recently completed by Army Engineers, will house "Betatron," one of largest X-ray machines ever built for revealing flaws in steel. With 24,000,000-v charge, Betatron can X-ray steel 7 in. thick in less than one minute and complete X-ray studies of component parts of tank turret castings in five hours in comparison with six months normally required. At ceremony at Eddystone plant of General Steel Castings Corporation on November 26, Lt. Col. W. H. H. Mullin, executive officer, Philadelphia District, Army Engineers, turned over the $500,000 facility to the Ordnance Department. Betatron building and equipment were designed by Jack S. Steele Company, Philadelphia, and construction is being performed under contract by Irwin & Leighton, also of Philadelphia.

Chicago Firm Engaged for ECA Survey in Philippines

The Chicago consulting firm of DeLeuw, Cather & Co. has been retained by the Philippine government to make an engineering and economic investigation and report on the government owned Philippine Railroad. A four man mission, headed by Philip R. Hffstrom, former vice president and general manager of the Chicago, Aurora & Elgin Railway, left for Manila on December 5 to initiate the survey, which is being sponsored by the Economic Cooperation Administration.

Recently the firm investigated and reported on the Makassan Work Shops of the Royal State Railways of Thailand in connection with financing by the World Bank.

Bids Asked for VA Hospital in Dallas

Bids will be accepted until February 12 for the construction of a 500-bed general surgical and medical addition to the Veterans Administration Hospital at Dallas, Tex. The project consists of a 4,311,000 cu ft hospital building, a recreation hall and chapel building, a duplex quarters building, and an addition to the existing boiler house, in addition to the usual servicing facilities.

Separate bids are being asked for (1) general construction, including roads, walks, fencing, grading and drainage; (2) electric elevators and dumbwaiters; (3) refrigerating equipment; and (4) laboratory equipment. Drawings and specifications are available upon application to the Director, Technical Service, Veterans Administration, Washington 25, D.C.

Highway Research Board Initiates Parking Survey

A diagnosis of the parking problem in its relation to the economic health of communities, retail business, and motor vehicle use will be made for the first time in a broad gauge study undertaken by the Highway Research Board. The two-year survey is intended to supply factual answers to such questions as the effect of offstreet parking shortage on downtown property values and taxes, on volume of trade in the business center, on street congestion, and on the full use of the family car. It will also seek to determine whether sufficient offstreet parking at moderate cost can be provided to satisfy the demand, and how such facilities can best be financed.

Funds for the project have been made available by the petroleum and automotive industries through the Automotive Safety Foundation. It is estimated that $75,000 will be required for the project. The Highway Research Board is directing the survey at the request of the Foundation, with specific phases of the research to be carried out at three or four selected university schools of business administration. The U.S. Bureau of Public Roads is loaning a staff engineer to the Board to correlate the university phases of the research.

World-Wide Guide for Training Sanitation Personnel Drafted

Establishment of adequately staffed services in every health administration to deal with problems of environmental sanitation was advocated by a committee of sanitary engineering experts from nine countries meeting recently in Geneva, Switzerland, under the auspices of the World Health Organization. The WHO Expert Committee on Environmental Sanitation is headed by Abel Wolman, M. ASCE, professor of sanitary engineering at Johns Hopkins University, who presided at the meeting. It includes representatives from the United States, the United Kingdom, Brazil, Chile, France, Italy, India, and Yugoslavia.

Taking cognizance of the wide discrepancies existing in the supply of sanitation personnel, in the organization of local health services, and in the economic, political, and social structure of the various countries, the committee stressed the importance of training everywhere specialists of the highest possible skill. They emphasized the need — "not recognized everywhere" — for using the best trained specialists in under-developed areas where problems arising from impure water, unsafe milk, and disease-carrying insects and rodents play an outstanding role. For more developed regions where the shortage of sanitation personnel is equally acute, the committee advocated, apart from the thorough training of sanitary personnel, development of sanitation units in all health administrations in order to carry out disease control as well as work in town, planning, housing, and industrial hygiene.

The need for teamwork at all levels of activity in environmental sanitation was also stressed by the committee, especially where several types of workers are required to carry out a balanced program of sanitation. It also recommended establishment of adequate centers for the education and training of different types of sanitation personnel. For the highest trained specialists, according to the committee, the creation of well-equipped centers on a regional basis is better than poorly equipped local centers.

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Wherever Reliable, Performance-Proved Pipe Is Needed, Specifications Call for Vitrified Clay

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Rapid City, S. D. (Air Base)	54,000 ft.
Eynon, Pa. (Gun Fire Control Plant)	120,000 ft.
Marion, N. C. (Municipal Expansion)	32,000 ft.
Needles, Calif. (Essential Ore)	87,000 ft.
Tucson, Ariz. (Air Base and Defense Plant)	440,000 ft.

Vitrified CLAY PIPE — CLAY PIPE NEVER WEARS OUT

C-152-1

Western Road Test Is Planned

A full scale test of bituminous pavement in southeastern Idaho will be carried out by the Highway Research Board in cooperation with ten state highway departments of the Western Association of State Highway Officials. Cooperating groups are the highway departments of California, Colorado, Idaho, Nevada, New Mexico, Oregon, Texas, Utah, Washington, and Wyoming, the Bureau of Public Roads, and the petroleum industry.

The test road will consist of two enclosed loops, each with two 1,000-ft straightaways of identical test pavement. Controlled test traffic consisting of two different prevailing weights of single-axle trucks will be used on one loop, and two different prevailing weights of tandem-axle trucks on the other. Pavement on the test sections will vary in thickness from 6 to 22 in., and the relative effects of the different types of test trucks on all sections will be determined and the results utilized in future design. Careful records of the cost of maintaining the various sections will be kept as an aid in determining the actual cost of each highway type.

Western contractors have been asked to submit bids on the test roads, which are to be completed early in August. Controlled test traffic will then be started on the test sections and operated until stopped by winter weather. The test will be resumed in the spring of 1953 and continued for about three months.

G.E. to Supply Equipment for New Aluminum Plants

Generators and turbines capable of producing 395,000 kw of electric power are included in a $20,000,000 order for General Electric equipment now being readied for installation in two new aluminum plants. Equipment amounting to almost $13,000,000 has been ordered by the Kaiser Aluminum Chemical Corp. for a new four-pot line reduction plant at Chalmette, La. A separate $8,000,000 order has been placed by the Reynolds Metal Co. for its two-pot line installation now under construction near Corpus Christi, Tex.

Both plants are expected to be in operation by the beginning of 1952. They will have an aggregate annual output of 550,000,000 lb of aluminum.

Soil Conservation Studied in Three River Basins

Eight teams of state and federal agricultural specialists are now at work on an inclusive soil conservation survey in the three river basins under study by the Arkansas-White-Red Basins Inter-Agency Committee, according to John A. Short, Assoc. M. ASCE, Department of Agriculture member of the committee. The teams, consisting of specialists from state agricultural colleges and federal workers with experience in the localities where they are working, are listing the specific conservation practices needed and plotting the number of acres that should be protected by each practice. The figures will provide needed data for the Inter-Agency Committee in the formulation of an overall plan of soil and water conservation and development. Teams have been assigned to each of the basin states of Louisiana, Missouri, Arkansas, Texas, Kansas, Colorado, Oklahoma, and New Mexico.

The final report on the 180,000,000-acre area is scheduled for completion in 1954. However, the soil conservation inventory and other preliminary steps will be completed earlier.

Mapping Instrument Tested for Military Allocation

TO FACILITATE military mapping, Engineer Research and Development Laboratories at Fort Belvoir are testing and evaluating Kelsh Plotter, new stereo-photogrammetric instrument. Designed by Harry Kelsh and developed by Geological Survey, new device is similar in principle to the Multiplex, standard Corps of Engineers mapping instrument. However, the Multiplex requires auxiliary equipment to correct for aerial camera lens distortion present in the aerial photograph, whereas correction device is built into the Kelsh Plotter. Additional advantage of the Kelsh Plotter is that the three-dimensional image projected is more highly resolved and at greater magnification than that projected by the Multiplex.

Synthetic Gravel Is Developed from Mud

Development of a process for producing synthetic gravel from mud is reported by Cornell University. Components in addition to mud are inexpensive chemicals and sulfite liquor, a waste product from the paper industry. Mixed in a "briquetting" machine, the material is fused into the shape of oversized dog biscuits, which may then be broken to resemble crushed rock. According to university authorities, the technique promises to solve a number of special problems in road building and other construction, particularly in places where gravel is scarce or non-existent.

In tests, individual pieces have been submerged in water for six months without disintegrating. They have withstood freezing and thawing and dropping from a three-story height. Experiments show that the binder is effective with a wide variety of soils, ranging from beach sands to heavy clays, and is not affected by organic contamination in the soil. Costs are said to be comparable to those for stabilization of soils with cement or asphalt, but the process has been found effective where other methods often are not.

The process was developed by Prof. Benjamin K. Hough, Assoc. M. ASCE, of the School of Civil Engineering, and Prof. Julian C. Smith, of the School of Chemical and Metallurgical Engineering, during a study of soil properties and stabilization. The research is sponsored by the Army Corps of Engineers.

Bid Calls to Be Issued for Reclamation Dams

Bid notices will soon be issued by the Bureau of Reclamation for work on four multiple-purpose dams, for which supplemental appropriations of $5,285,000 were made available in the recent closing sessions of Congress.

Of these funds $2,000,000 will go toward construction of the $76,601,000 Palisades Dam and Power Plant in Idaho, which will have a potential hydroelectric power capacity of 114,000 kw for defense and domestic use. The project will also supply supplemental water for about 650,000 acres of land. Two of the dams are part of the Missouri River flood control system. Some $2,500,000 was appropriated for Kirwin Dam, an $18,187,000 structure on the Solomon River near Kirwin, Kans., the area devastated by floods last summer. Jamestown Dam on the James River in North Dakota received $500,000 for initial construction on a $10,628,000 project. It will provide 540,000 acre-ft of storage for flood control and municipal supplies. Irrigation features for both projects will be developed later. An initial appropriation of $285,000 was made for the $2,664,000 Vermejo irrigation project near Maxwell in northeast New Mexico. The plan calls for enlarging three existing reservoirs and creating a new one for flood and silt control.

AUTHORITIES and other public bodies during recent years have financed a growing volume of needed facilities on a pay-as-you-go basis through the medium of Special Revenue Obligations rather than Bonds payable from general taxation.

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Joe," began the Professor, "if a quadrilateral is cut diagonally into 4 triangular ..."

"I remember," interrupted Joe Kerr "Obviously, if all sides are integers and area of each triangle equals its perimeter, the triangles are right, and we have

$$a^2 + b^2 = c^2 \quad (1)$$

$$\frac{1}{2}ab = a + b + c \quad (2)$$

Now (1) is satisfied by the familiar generators $a = m^2 - n^2$, $b = 2mn$, and $c = m^2 + n^2$. Substituting these in (2) leads to $n(m - n) = 2$, for which, by inspection, the only solutions in positive integers are $m = 3$, $n = 1$ or 2, generating the two triangles 8,6,10 and 5,12,13. Since no two sides are equal, I had to fit 4 of either kind into the quadrilateral. Either way, the 4 sons were of the same age at their last birthdays, so I guess the "3 younger sons" were triplets born 11 months after the eldest. Is that an answer?"

"I don't think so, for one," mused Cal Klater. "We were asked the age of the eldest, not how much older he was than the others. Besides, Joe jumped at right triangles when he should have started with the general heronian equation:

$$A^2 = s(s - a)(s - b)(s - c) \quad (3)$$

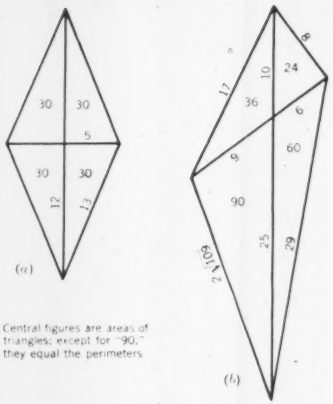
$$A = P = 2s = a + b + c \quad (4)$$

If we let $t = s - a$, $u = s - b$ and $v = s - c$ then $s = t + u + v$ and (3) becomes

$$tuv = 4(t + u + v) \quad (5)$$

in which we can specify $0 < t \leq u \leq v$. It doesn't take many trials to find that there are just 5 solutions to (5): $t = 1$; 2; $u = 5,6,8$; $3,4$; and $v = 24,14,9$; $10,6$. Substituting back, we find Joe's right triangles and 6,25,29; 7,15,20; 9,10,17.

"For 3 of these triangles to fit in a quadrilateral, there must be two common sides, which must be 6 and 10 because no others are repeated. The sketch shows how. The 4 areas are 24, 36, 60 and 90, which are proportional to only one set of minor ages, 4, 6, 10 and 15. So the age of the eldest was 15."



Central figures are areas of triangles; except for "90," they equal the perimeters.

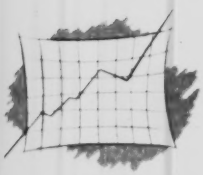
FIG. 1. JOE KERR presumed triplets (*a*), but Cal proved (*b*) a more likely sequence.

"I agree with Cal," added Ken Bridgewater, "but first I figured some pretty big ranches when I presumed you wanted area in acres to equal perimeter in feet."

"If you want to use acres," concluded Professor Neare, "better reckon distance in chains. There are six right triangles ranging from 234 to 1,722 acres, and plenty of others.

"For a timely New Year problem, consider the 1952 employees in the SPA (Surplus Personnel Administration). The SPA started humbly in 1944, more than doubled in 1945 and thereafter added as many new employees at the beginning of each year as had been added in the preceding biennium. In 1953 there will be 11 times as many as were added in 1950, and in 1957, 29 times as many as were just added this year. How many will there be in 1961?"

[Cal Klaters were: Ed C. Holt, Jr., A. Nather Nutt, Richard Jenney, Stoop (John L.) Nagle, S. L. Dum (Thomas M. Borman), Charles W. Trigg, Julian Hinds, R. E. Phillen, Wm. C. Hunter, and Thatcherite (Guy C. Thatcher). Also acknowledged is Sauer Doe (Marvin) Larson's solution to the October perfect canal problem.]



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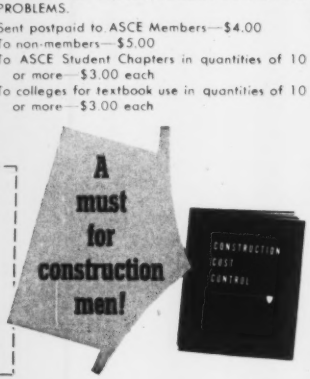

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Film Shows Labrador Railroad Construction

Availability of a 16-mm kodachrome silent film depicting construction of the Labrador Railroad and iron ore development in the Knob Lake-Burnt Creek district of Labrador (November issue, page 66) is announced by Armco Drainage & Metal Products, Inc. The film, which runs about 30 minutes, is recommended for showing to engineering groups, college students, and other technical groups.

Arrangements for booking can be made through division offices of Armco Drainage & Metal Products, Inc., or by writing directly to the headquarters of the company in Middletown, Ohio.

The Surveyor's Notebook

Reporting on Unusual Surveying Problems and Their Solutions

Notekeeper: W. & L. E. Gurley, America's Oldest Engineering Instrument Maker

Finding the Frozen Facts

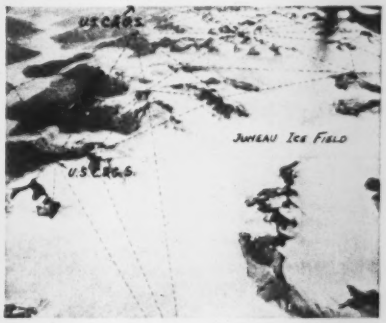
"Bringing horizontal and vertical surveying control into some 500 square miles of mountain and glacial wilderness was my job on the Juneau Ice Field Research Project in 1949-50," writes Richard G. Merritt. Then a Yale undergraduate, Merritt was chosen to head the surveying for investigations supported by the American Geographical Society of N. Y., the Office of Naval Research and other organizations. He qualified through experience as a skier and mountain climber; he could handle arctic and alpine problems as well as a transit.

"My first problem in this maze of peaks, snow fields and glaciers was starting the triangulation system. The U. S. Coast and Geodetic Survey had extended third-order control to the edge of the ice field at two points, 13 miles apart. What could be more ideal: a base line as long as my longest sights. Measuring an accurate base of any length in glacier snow would be impossible.

"For stations, I chose mountain summits—a decision I sometimes regretted when reaching them became difficult. The actual surveying was the easiest part. We merely set up and shot a complete circle.

COURTESY AMERICAN GEOGRAPHICAL SOCIETY, N. Y.

Triangulation station at 5260 feet in Juneau Ice Field: Richard Merritt reads Gurley Transit.



AIR FORCE PHOTO

Air view of 500 square miles of Juneau Ice Field with the principal triangles in Merritt's system.

"Surveying also played an important role in determining the rate of surface movement of the main Taku Glacier across several profiles. This problem was unique, requiring Christmas tree-like flags placed on the glacier and positioned by triangulation. We found Taku moved as much as three feet a day at its fastest point, the center.

"The Gurley Was My Pride"

"It required roped climbing to reach most of our stations. We couldn't travel safely with packs on our backs, but hauled them up on the end of the rope. Our Gurley Transit proved stout and sturdy—had to be, to stand being dragged up perpendicular rock faces. I was worried every time the transit box bounced against the side of a peak, for the Gurley was my pride. But nothing seemed to phase that transit—not even bad ski falls. It remained in perfect adjustment."

We'd like your story for a future page in this series. Drop us a line... we'll contact you for details later. Ask for Bulletin 50 giving complete data on Gurley instruments.

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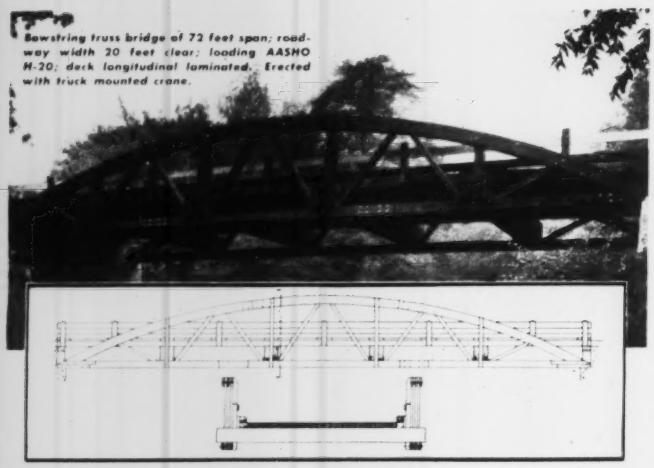

Bowstring truss bridge of 72 feet span; roadway width 20 feet clear; loading AASHO H-20; deck longitudinal laminated. Erected with truck mounted crane.

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NEW IN EDUCATION

The second annual quality concrete short course will be held at Georgia Institute of Technology, Atlanta, February 4-6. Prof. R. J. Paquette will direct the course, which is being conducted by the School of Civil Engineering. The course offers laboratory participation and comprehensive instruction on the design and control of concrete mixtures, placing, and forms and curing.

Announcement of teaching assistantships graduate fellowships, and research assistantships for the academic year 1952-1953 is made by the Carnegie Institute of Technology College of Engineering and Science. The assistantships carry remission of tuition and fees amounting to $600 and cash stipends ranging from $750-$1,100. Graduate fellowships, supported by outside agencies and special Carnegie funds, carry grants based upon need, up to $2,100 in addition to tuition. Address inquiries to Dean of Graduate Studies, College of Engineering and Science, Carnegie Institute of Technology, Pittsburgh 13, Pa.

The Research Division of the New York University College of Engineering has organized a new section on air and water pollution research, according to an announcement from Dr. Harold K. Work, director of the division. The section, consisting of a panel of seven specialists to study air and water pollution problems, includes Gail P. Edwards, M. ASCE, professor of sanitary chemistry, and William T. Ingram, Assoc. M. ASCE, associate professor of public health engineering, who is executive secretary of the section.

To meet demands for qualified personnel in the broadening field of sanitation, Rensselaer Polytechnic Institute has been promoting a curriculum in sanitary engineering during the past two years. The program, leading to a bacheler's degree in civil engineering with sanitary option, includes courses in environmental sanitation, principles of sanitation, water purification and sewage treatment, stream sanitation, and sanitary works design. Research in the field will be developed at the sanitary engineering laboratory.

The graduate faculty of Lehigh University Department of Civil Engineering and Mechanics has approved the offering of the degree of Master of Science in Engineering Mechanics. Involving 30 hours of credits, the program is available to those who have the equivalent of a Lehigh degree of Bachelor of Science in Engineering.

The 1951-1952 welding prize competition and program of awards, conducted by the Eutectic Welding Alloys Corp., is announced. Participants may submit papers on "Welding Engineering and Theory" and "Practical Welding Applications." A

total of 30 cash prizes amounting to $2,000 will be awarded. For a complete set of rules, entry blank, and suggestions on the preparation of papers address the Eutectic Welding Alloys Corp., Department P, 172nd Street and Northern Blvd., Flushing, N.Y.

Tests on prestressed concrete will be continued this winter at Stevens Institute of Technology by students working for the Mahler Award, established last year to stimulate interest in the testing of materials. The award, consisting of membership in the American Society for Testing Materials for up to five students, is offered annually and made on the basis of special investigation in the field carried out during the student's senior year.

Model tests for a 275-ft sludge vessel for the City of New York have been completed at the Experimental Towing Tank at Stevens Institute of Technology. The vessel, to be used by the Division of Sewage Disposal of the Department of Public Works, was designed by Philip L. Rhodes and is now under construction by John H. Mathis of Camden, N.J. It will be used to dispose of residue from sewage processing in the Atlantic Ocean off Ambrose Lightship.

Ohio State University has received an unrestricted grant of $7,500 from the Republic Steel Corp. to help support research studies on industrial waste disposal. The investigations will be conducted at a pilot plant now under construction on the east bank of the Olentangy River. The Ohio Legislature has authorized the studies and allocated $100,000 to the State Water Resources Board for the research, which will be conducted by the Engineering Experiment Station.

Initiation of a doctor of philosophy program in irrigation engineering at Colorado A. & M. College is announced by Dean T. H. Evans. The first doctorate to be offered by the college, the degree will be administered by the civil engineering department. The work will be given in conjunction with programs of the Irrigation Institute and can include theoretical or applied fluid mechanics, design, soils and water, operation and management, and project planning. A limited number of teaching and research fellowships will be available.

Chemicals that promise to aid in control of soil erosion are undergoing tests at Ohio State University. Research began last December at the Engineering Experiment Station there to determine effectiveness of the chemicals in "anchoring" soil samples taken from various parts of the country and subjected to erosion action of artificial rain. Chemical treatment of the soil surface reduced the damaging effects of rainfall by as much as 15 times, and test plots have now been established to obtain field confirmation of these results. Louis J. Goodman, assistant professor of civil engineering, is supervisor of the research project, which is sponsored by the Navy Bureau of Yards and Docks and administered through the Ohio State University Research Foundation.

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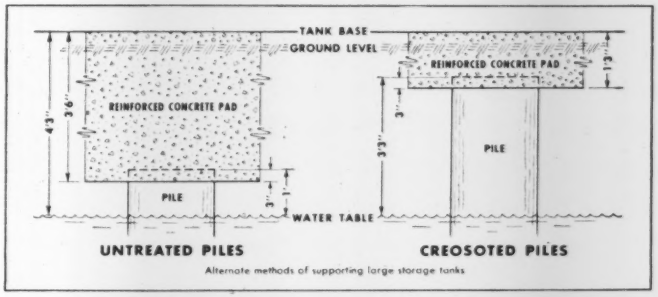

Alternate methods of supporting large storage tanks

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AT THE Williams Plant in Port Arthur, Texas, foundations were recently installed for six large storage tanks. These tanks are on ground that is slightly above the permanent water table. Under such conditions it is common practice to use *untreated* timber piles for foundations.

But *untreated* piles, as shown above, may require a *thick* pad of concrete—and that runs into real money. This thickness of concrete may be necessary because untreated piles cannot be cut off any higher than one foot above the permanent water table; otherwise they are vulnerable to decay and insect attack.

Koppers *Pressure-Creosoted* Piles, on the other hand, are fully protected against decay and insects . . . they can be cut off *at any point above the permanent water table.* A thinner pad of concrete is all that's needed—and the costs are much lower.

That's why the Williams' tanks were founded on Koppers Pressure-Creosoted Piles. The estimated savings in material and labor, based on Gulf Coast prices, are set forth below. These figures cover all six storage tanks—five tanks with a capacity of 500,000 gallons each, and one tank with a capacity of 1,500,000 gallons.

Comparative Costs

USING UNTREATED PILES		USING CREOSOTED PILES
1,479	Number of Piles	1,320
35'	Length of Piles	35'
2,610	Cu. Yds. of Concrete	930
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1,930	Cu. Yds. of Excavation	432
$180,850	Total Cost	$147,338

$180,850
147,338
Savings—$33,512

Use of untreated piles would have increased foundation costs by 22.7%.

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DECEASED

Samuel Baker (M. '31) of Scranton, Pa., died on November 14, at the age of 58. Early in his career Mr. Baker was assistant principal and principal of civil engineering for the International Correspondence Schools in Scranton, Pa.; bridge designer for J. A. L. Waddell in New York City; and designer for the Erie Railroad in New York. In 1926 he returned to I.C.S., becoming director of the civil engineering schools, associate dean of the schools of technology and director of the civil engineering schools, and vice-president and dean of the schools of technology, retiring in 1948. He received his engineering degrees from Cooper Union.

George William Booth (M. '08) retired engineer of Glen Gardner, N.J., died on October 2. He was 80. Upon his graduation from Worcester Polytechnic Institute in 1891, Mr. Booth became an instructor in civil engineering there. He worked successively for E. Worthington Jr. & Co., of Boston, Mass.; the Massachusetts State Board of Health; and the Metropolitan Water Board of Massachusetts. Except for one year with the New York City Department of Water Supply, Gas and Electricity, Mr. Booth had served the National Board of Fire Underwriters from 1904 until his retirement.

John Francis Devine (Jun. M. '49) engineer for the Wisconsin State Highway Commission, at Milwaukee, Wis., died recently. He was 26 and a graduate of Marquette University, where he had been a member of the ASCE Student Chapter.

Leroy L. Hidinger, Former ASCE Director, Is Dead

Leroy Lemayne Hidinger (M. '16) for the past 36 years president of the Morgan Engineering Co., of Memphis, Tenn., died on November 11. He was 72. Mr. Hidinger became a partner in the Morgan Engineering Co. in 1910. An expert on flood control and drainage engineering, he worked on such projects as the Little River Drainage District in Missouri, the Wichita River Project in Texas, and the Trinity River Project in Dallas. Earlier he had been engaged as drainage engineer by the federal government. He served the Society as Director (1936–1938) and as president of the Mid-South Section. He received his degrees from Iowa State College and was Marston Medalist in 1942.

Leroy L. Hidinger

(*Continued on page 135*)

Philadelphia's Independence Hall, where the Liberty Bell is housed, as it looked 100 years ago

Philadelphia has cast iron water and gas mains in service that were laid well over a century ago. One of them is America's oldest cast iron water main, still functioning despite the radically changed conditions of street traffic and underground utility services in 100 years. The fact that cast iron pipe, laid generations ago, withstands the shock of heavy-duty traffic and the stresses caused by congested underground structures, amply demonstrates its shock-strength and beam-strength. Because of these strength factors and effective resistance to corrosion, cast iron water and gas mains, laid over 100 years ago, are still serving in the streets of more than 30 cities in the United States and Canada. **United States Pipe and Foundry Co., General Offices, Burlington, N. J. Plants and Sales Offices Throughout the U. S. A.**

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Men Available

CIVIL ENGINEER. Assoc. M. ASCE. 33, married, veteran. B.S. in C.E., 3½ years experience, field and office, on railroad, heavy earthwork and reinforced concrete construction, 4½ years as hydraulic and structural designer of reinforced concrete hydraulic structures, conduits, canals, and pumping plants. Familiar with specification writing and administrative experience as design section head. C-708-5110-A-4-San Francisco.

RESEARCH ENGINEER. Aff. M. ASCE; graduate work physics and business administration. Ph.D. mathematics; research and publications pure and applied mathematics; extensive experience in economic justification engineering projects, highway planning, studies of highway, city street traffic, service life physical property, scientific inventory control, quality control manufactured products, teaching college mathematics, fire technology, report writing. C-709.

CIVIL ENGINEER. Assoc. M. ASCE; from India with a master of science degree in Civil Engineering (advanced structures) and with a year's specialized training in various highway and dam structures in the United States seeks administrative or technical position with any civil engineering concern in the United States of America or Canada. C-710.

ENGINEERING OR GENERAL MANAGER. Assoc. M. ASCE, with broad administrative experience in research, design and fabrication of metals, plastics and other materials in structures. Training also in business, personnel, sales. Many years' experience solving difficult structural problems when unusual conditions required starting from scratch. Ph.D. applied mechanics plus 15 years' practical experience. C-711.

Positions Available

SANITARY ENGINEERS; 35-40; to design and draw up sewage systems and treating plants, etc.; with knowledge of water producing and distribution. Should have about 10 years' practical experience in addition to a degree in sanitary engineering. Location, Virginia. Y-6120.

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SANITARY ENGINEER to take charge of sanitary facilities on highway construction project in tropics. Must be United States citizen. Physical examination required. Single status. Must have had some Latin American experience. Salary, $6,000-$8,000 a year plus living allowance. Location, Bolivia. Y-6303.

ENGINEERS. (a) Civil, structural, or building construction engineer, graduate, 35-50; preferably 10 years' design experience, including work on industrial projects; service with 1 or more of the country's larger engineering firms, a minimum of 5 years' responsible experience in the supervision of construction and/or other duties in the field. Salary, $8,000-$10,000 a year. (c) Resident Engineer, civil or structural, for construction of industrial buildings. Salary, $6,500-$8,000 a year. Location, upstate New York. Y-6304.

PROJECT ENGINEER, civil and architectural, with experience in office and institutional type buildings. Considerable traveling. Salary, $7,500 a year. Headquarters, Washington, D.C. Y-6359.

Positions Announced

City of Norwich, Conn. A position as Director of Public Works for the City of Norwich, Conn., is open to a civil engineer with experience and licensed by the State of Connecticut. Salary open with opportunity for increases. Position requires organizational and administrative ability. Applicants need not be residents of Connecticut.

California State Personnel Board, Sacramento. California's new water pollution control program needs competent water pollution control engineers. Information is available from the California State Personnel Board, 1015 L Street, Sacramento, Calif.

Department of the Army. Announcement of engineering opportunities in Alaska, Puerto Rico, Japan, Okinawa, and Austria, is made by the Department of the Army. Positions include engineering draftsman, at $3,410-$4,205 per year; civil engineers, at $3,410-$7,040 per year; hydraulic engineers, at $4,205 per year; construction engineers, at $4,205-$5,940 per year; structural engineers, at $3,410-$5,940 per year; construction management engineers, at $4,205-$8,360 per year; and others. Complete information may be obtained from the New York District of the Corps of Engineers, Department of the Army, 80 Lafayette Street, New York, N.Y., Attention: Mrs. Sternlicht, Personnel Branch.

Minnesota Society of Professional Engineers. The Minnesota Society of Profes-

(*Continued on page 134*)

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Positions Announced

(*Continued from page 133*)

sional Engineers is seeking a state executive secretary, at a starting yearly salary of $4,200-$5,000 depending upon experience. Applicant must be a college graduate with experience adaptable to the duties of the position. Duties include the administration of the Society with responsibility for keeping all records, compiling reports on activities, and supervising clerical assistant. Address inquiries to the Minnesota Society of Professional Engineers, Executive Committee, 1000 Guardian Building, St. Paul 1, Minn., before January 15.

U.S. Civil Service Commission. Announcement of an examination for the positions of Cartographer and Cartographic Aid, with yearly salaries ranging from $2,200-$7,600, and for Cartographic Draftsman, with yearly salary from $2,200-$3,825, is made by the U.S. Civil Service Commission. The positions are located in Washington, D.C., and its vicinity. Full information and application forms may be secured from local post offices, regional civil service offices, or the U.S. Civil Service Commission, Washington 25, D.C.

Non-ASCE Meetings

American Institute of Electrical Engineers. Headquarters for the winter general meeting of the American Institute of Electrical Engineers will be the Hotel Statler, New York City, January 21-25.

American Road Builders' Association. The 50th anniversary meeting of the American Road Builders' Association will be held at the Rice Hotel in Houston, Tex., January 21-24.

American Society of Heating and Ventilating Engineers. A symposium on the control of industrial atmospheres will be presented at the 58th annual meeting of the American Society of Heating and Ventilating Engineers at the Statler and Jefferson hotels, St. Louis, Mo., January 28-30.

American Society for Metals. Aspects of strategic metal conservation and substitution will be discussed at the midwinter technical meeting of the American Society for Metals at the William Penn Hotel, Pittsburgh, Pa., January 31 and February 1.

Associated Equipment Distributors. Headquarters for the 33rd annual convention of Associated Equipment Distributors will be the Conrad Hilton Hotel, Chicago, Ill., January 27-31.

California Conference on Street and Highway Problems. The Fourth California Conference on Street and Highway Problems will take place at the University of California, Los Angeles, February 6-8, under sponsorship of the university's Institute of Transportation and Traffic Engineering.

Highway Research Board. The annual meeting of the Highway Research Board of the National Research Council will take place in the building of the National Academy of Sciences and the National Research Council, Washington, D.C., January 15-18.

Plant Maintenance Conference and Exposition. The Plant Maintenance Conference and Exposition will be conducted simultaneously in Convention Hall, Philadelphia, Pa., January 14-17.

Society of Automotive Engineers, Inc. The annual meeting of the Society of Automotive Engineers, Inc., is scheduled for the Hotel Book Cadillac, Detroit, Mich., January 14-18.

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Deceased

(*Continued from page 130*)

Milo Pitcher Fox (M. '42) with the Corps of Engineers at Galveston, Tex., died on July 21, at the age of 64. During his career with the Corps Mr. Fox had been district engineer at Wilmington, N.C., Huntington, W.Va., Galveston, Tex., and Portland, Oreg. He later became assistant to the Chief of Engineers on river and harbor work; resident member on the Board of Engineers for Rivers and Harbors; and assistant to the president and secretary of the Mississippi River Commission. He was educated at the U. S. Military Academy.

George Sherman Frost (Assoc. M. '03) retired engineer of Philadelphia, Pa., died on October 25. His age was 78. Mr. Frost had been engaged by Naughton & Co., the New York Telephone Co., and the Rapid Transit Commission and Public Service Commission of New York. Later he was with the Philadelphia Bureau of Water, Eastern Clay Products Association, and the City Department of Transit in Philadelphia. He was a graduate of the University of Maine.

Satya Sadhan Ghosh (Assoc. M. '49) since 1944 assistant inspecting officer for the Department of Industry and Supply, Government of India, at Calcutta, died on March 3, according to word just received at Society Headquarters. He was 39 and a graduate of Bengal Engineering College. He entered the employ of the Government of India at Tatanagar in 1940, becoming examiner of stores (structural) and assistant inspecting officer in Calcutta.

Louis Carl Grossmann (Assoc. M. '39) for a number of years project engineer for the Federal Public Housing Authority, at North Wilmington, Mass., died on September 30, at the age of 66. Mr. Grossmann began his career with Clinton J. Warren, Boston, Mass., architect. From 1908 to 1915 he was with Norcross Bros. at Worcester, and later was assistant district engineer in charge of public buildings in New England. He received his engineering training at Northeastern, Massachusetts, and Wisconsin universities.

Edgar Augustus Groves (M. '24) retired engineer of New York, N.Y., died on November 25. His age was 69. Born in Birmingham, England, Mr. Groves spent his early career in England, coming to the United States in 1905. He was successively chief engineer and manager for the Mason & Hanger Co., Arthur A. Johnson Corp., and Moranti & Raymond, all New York contractors. From 1935 to 1943 he was manager of the Staten Island, Manhattan, and Queens districts of the Federal Works Agency and was supervising engineer for the Defense Plant Corp. in Pittsburgh from 1943 until his retirement in 1948. He studied engineering at Birmingham University.

(*Continued on page 138*)

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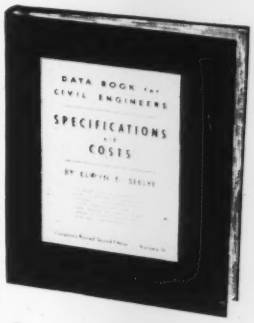

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The Readers Write

(Continued from page 103)

surface, would open up joints enough to cause leakage.

While my article and sketch did not discuss detailed design, I think sufficient steel reinforcement, properly placed, in the buttress walls could reduce the downstream deflection enough to prevent such leakage without necessitating extensive up and down reinforcement in the curved slab. If considered necessary, the device can be used of inserting into the joints folded strips of non-corrosive sheet metal bonded into the concrete above and below the joint. This type of device has been used. The principal reinforcement in the slab should of course be designed to transmit the load and pressure from the slab to the buttress walls by either simple or continuous beam action.

It might be advisable in many cases to make comparative designs and estimates of both the slab and the multiple-arch methods of carrying the loads to the buttresses.

It would probably be advisable to use reinforced concrete connectors between the buttress walls and some of these could be utilized to help support forms for the slab.

Mr. Schmidt's discussion of problems encountered where the dam foundation is on "limestone or other cavernous rock" is very interesting. If leakage from such cavities is very extensive it would seem to indicate an ineffective exploration of the foundation rock. The mere presence of apparently good "bedrock" at the stream bed is not necessarily a guarantee of a good foundation, as evidenced by the two Austin dam failures, one in Texas and the other in Pennsylvania.

If leaks from such cavities are not very great, perhaps the buttress-type dam would not involve any more difficulty or expense in repair than the gravity type. My experience in the construction of many successful cofferdams leads me to think that unless the tailwater below the buttress dam is very deep, it would not be too difficult to construct a cofferdam against the edges of the buttresses of one or more of the bays or compartments between the buttresses. Then, after pumping out, the drilling and grouting equipment could be installed and operated at locations within 20 or 30 ft of the back of the cutoff wall, very probably giving better results in stopping the leaks than would be obtained by drilling down through the full height of a gravity dam.

In my article in the June issue, there was no intention to limit the upper and lower slopes of the dam to 60 and 30 deg respectively. Those were merely the slopes used in the illustrative sketch.

HORACE P. BOARDMAN, M. ASCE
Consulting Civil Engineer
Reno, Nev.

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Brazilian Underground Power Station Not World's Largest

TO THE EDITOR: In the process of arranging the editorial makeup for the second part of the story on the Paraiba-Pirai hydroelectric development in Brazil (CIVIL ENGINEERING, November, pp. 46–50) by the writer, Franklin T. Matthias, and George O. Vogan, a special title was introduced which lays claim to "the world's largest underground power station."

Unfortunately, the little words "one of" were omitted. Don't be surprised if

you hear from Canada, Sweden, Switzerland or Italy about this. The Kemano underground project in British Columbia, now under construction, will undoubtedly hold this record for a long time.

ADOLPH J. ACKERMAN, M. ASCE
(for the authors)
Mankato, Minn.

Effect of Horizontal Earthquake Shock on Dams

TO THE EDITOR: The article, "Hydrodynamic Pressure Due to Horizontal Earthquake Shock Computed by Curves," by Ven Te Chow in the September 1951 issue, is interesting and may do much to stimulate further discussion toward the solution of a challenging problem.

Unfortunately the method overlooks a basic hydrodynamic principle. Since the face of a dam is a streamline and no water can escape across it, the velocity of a particle normal to the surface of the dam is zero, and the particle can have no displacement in that direction. Thus, the author's assumption of $\beta = F(S)$ is incorrect. The hydrodynamic pressure due to earthquake acceleration is not the same as if the area between the sloping line, 1–S, and the face of the dam were filled with concrete.

Mr. Chow's solution is, by coincidence, identical with a method suggested by U.S. Bureau of Reclamation Technical Memorandum No. 607, August 1, 1940. However, this method is no longer used.

C. N. ZANGAR, Assoc. M. ASCE
U.S. Bureau of Reclamation
Denver, Colo.

Invasions Blamed for Ruin of Ceylon's Irrigation Works

TO THE EDITOR: I read with interest the description of the ancient irrigation works of Ceylon by Mr. von der Lippe in the September issue. The author has, while giving an idea of the magnitude and scope of these works, made a questionable statement regarding the cause of their decay. Ceylon is not subject to the very violent rain storms referred to. In fact the precipitation of 31.7 in. in the day referred to occurred at a station in the northeastern corner of the island, and has not been equaled since, either at this station or at any other for which records are available.

The ancient engineers did know the magnitude of the forces of nature in their own environment. The author himself, referring to the Pandawewa Reservoir, says that "the height to which the floods would rise over the rock [spillway] had been correctly estimated." The existence of several tanks which have functioned continuously since their construction, should make us look for circumstances other than faulty design to explain the ruin of these works.

It is my belief that the waves of invasion from India, from Portugal, from Holland and finally from Britain, were responsible for their destruction. In 1834 the British Government framed a piece of well meant but misguided legislation and abolished the *rajakariya* or "duty labor" system by means of which irrigation works had been maintained. After this legislation was enacted, the disintegration of the remaining works went on apace until a succession of famines in the north central province opened the eyes of the rulers to their responsibilities.

H. DE S. MANAMPERI
(Irrigation Engineer, Government of Ceylon)
State University of Iowa
Iowa City, Iowa

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Deceased

(Continued from page 137)

Willard Adams Guild (M. '21) retired railroad engineer of Topeka, Kans., died on August 30, at the age of 73. After graduation from Washburn College in 1902 Mr. Guild entered the employ of the Atchison, Topeka & Santa Fe Railway, at Fort Madison, Iowa. He spent his entire career with the railroad, serving in various engineering capacities including division engineer, district engineer, and assistant chief engineer.

Jack Arthur Haine (M. '50) engineer for the United Water Conservation District, at Santa Paula, Calif., died on October 20, at the age of 46. Mr. Haine was first connected with the Water Department of Los Angeles, Calif.; the City of Santa Monica, Calif.; and Kreutzer Aircraft Co., at Venice, Calif. Later he joined the U.S. Bureau of Reclamation, serving successively as materials engineer, at Buelah, Oreg., and assistant engineer, associate engineer, and engineer at Denver, Colo. He also worked for Acueducto Municipal in Bogota, Colombia, South America. He attended the University of California.

Gene William Hall (M. '45) civil engineer and partner in the New York engineering firm of Parsons, Brinckerhoff, Hall & Macdonald, died on November 30. His age was 53. General Hall spent most of his career with Parsons, Brinckerhoff, Hall & Macdonald and its predecessor organizations, becoming partner in the firm in 1938. From 1936 to 1938 he was consultant to Gen. Brehon Somervell in the remodeling of Fort Schuyler into the New York State Merchant Marine Academy. During the second World War he served the Army Corps of Engineers in the Caribbean and China-India-Burma theatres.

William McLaurine Hall (M. '93) retired civil engineer of Parkersburg, W.Va., died on November 25. He was 91. Mr. Hall's early experience included work for several railroads in New York and Pennsylvania and the New Croton Aqueduct development. In 1893 he became connected with U.S. Engineers serving them until his retirement in 1932. He graduated from the U.S. Military Academy and received an honorary doctor of science degree from Marietta College in 1947.

William Sherman Hewett (M. '09) retired structural engineer of Evanston, Ill., died on November 20, at the age of 87. Mr. Hewett began his career with S. M. Hewett, bridge engineer of Minneapolis, Minn. From 1897 to 1921 he was president and engineer for the Security Bridge Co., at Minneapolis. He then established his structural engineering concern, practicing for many years in Chicago, Ill.

William Ambrose Kinsey (M. '19) consulting and contracting engineer of Newark, N.J., died on October 29, at the age of 79. From 1896 to 1908 Mr. Kinsey was affiliated with the Hedden Iron Co. He then formed his own consulting and contracting engineering business in Newark, where he practiced for many years.

Julius Stephen Kunkel (Assoc. M. '11) retired engineer of Tampico, Mexico, died on October 31. His age was 69. At the start of his career Mr. Kunkel worked for the Mexican Central, the Interoceanic, and Vera Cruz & Pacific railways. He was later connected with the Huasteca Petroleum Co., at Tampico. He attended the University of Kansas.

William Wallace Laxton (Assoc. M. '25) engineer for the Corps of Engineers, at Portland, Oreg., died on September 29. He was 61. Mr. Laxton did general construction in his early career. In 1929 he became field inspector for the Army Corps of Engineers in Portland, Oreg., later serving as assistant engineer, supervising engineer, and associate engineer on Bonneville Dam.

Edgar Darwin Martin (M. '09) architect and engineer of Chicago, Ill., died on September 17, at the age of 80. Mr. Martin was a partner in the firm of Schmidt, Garden & Martin, Chicago, from 1906 to 1923. He was then engaged by the State of Illinois and the Chicago Board of Education and later became a member of the firm of Pond, Pond, Martin & Lloyd.

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Edward Bromley Mayer (M. '36) for some time engineer for the Los Angeles Department of Water and Power, Los Angeles, Calif., died on April 5, according to word just received at Society Headquarters. His age was 60. Mr. Mayer was previously associated with the Bureau of Water Works and Supply in Los Angeles, serving as engineer in charge of the water cost division and executive assistant to the general manager and chief engineer.

Justin Nicolet (Assoc. M. '29) structural engineer for the Department of Subways and Superhighways, Chicago, Ill., died on October 22, at the age of 60. Mr. Nicolet had been designing engineer for the Sinclair Refining Co., estimating engineer for the U.S. Gypsum Co., and civil engineer for V. D. Timons, Inc., and the Harza Engineering Co. In 1937 he joined the City of Chicago Department of Subways and Superhighways.

Frederick Pitzman (M. '27) president and chief engineer of Pitzman's Company of Surveyors and Engineers, at St. Louis, Mo., died on November 17. He was 61. Mr. Pitzman had been engaged in engineering and surveying work at Scott Aviation Field near Belleville, Ill., Camp Funsten, Kans., and Fort Sill, Okla., and for some time was in private practice in St. Louis.

Edward Leo Price (M. '4" with Francisco & Jacobus, at Richmond, Va., died on August 8, at the age of 53. Mr. Price had been engineering assistant and inspector for the City Engineering Department of Charleston, S.C.; assistant engineer for the Port Utilities Commission, at Charleston; and engineer for several architectural and engineering firms in Charleston and New York City. He later served as resident engineer for the Public Works Administration, senior civil engineer for the Corps of Engineers, and marine engineer for the Charleston Shipbuilding and Dry Dock Co.

Clyde Charles Pugh (M. '45) since 1935 assistant engineer for the Hazel-Atlas Glass Co., at Wheeling, W. Va., died on November 6. He was 60. Upon his graduation from West Virginia University in 1912, Mr. Pugh entered the employ of the Wheeling (W.Va.) Traction Co. He was subsequently assistant engineer for the West Virginia Traction and Electric Co.; engineer and vice-president for the C. B. Kimberly Co.; and engineer with the C. C. Smith Co. From 1921 to 1935 he was a member of the firm of Conrad & Pugh.

Edward Peter Shuman (M. '07) of Allentown, Pa., died on August 9. His age was 78. During his career Mr. Shuman had worked for the Lehigh Engineering Co., the Michigan, Lake Superior Power Co., and the Algoma Central Railroad. He did sanitary engineering and public improvement work for the government in the Philippine Islands for a number of years.

(Continued on page 140)

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Deceased

(Continued from page 139)

Frank Charles Starr (M. '20) construction specialist in the Office of the Housing Expediter, at Lexington, Mass., died on June 11, at the age of 70. Earlier in his career Mr. Starr taught civil engineering at Massachusetts Institute of Technology, his alma mater, and George Washington University. For some time he was a member of the firm of Mechlin & Starr in Washington, D.C.

NEWS OF ENGINEERS

William W. Wanamaker, brigadier general, U.S. Army (retired), has resigned as executive director of the New Jersey Turnpike Authority to accept an appointment as chief engineer of the Orinoco Mining Company, a Venezuelan iron ore mining subsidiary of the U.S. Steel Corporation. A graduate of West Point in 1918, General Wanamaker has been U.S. district engineer for several districts of the Corps of Engineers in charge of construction activities. During the recent war he served as chief transportation officer in the Southwest Pacific in charge of operation of all shipping and port operations during the New Guinea and Philippine campaigns, receiving the Distinguished Service Medal, the Legion of Merit, and the Bronze Star with V. He retired from active service in November 1949 to become executive director of the New Jersey Turnpike.

General Wanamaker

Philip C. Rutledge, since 1946 chairman of the civil engineering department of the Technological Institute at Northwestern University, joined the New York City consulting engineering firm of Moran, Proctor, Freeman & Mueser on January 1 as a partner. The firm name is being changed to Moran, Proctor, Mueser & Rutledge. George L. Freeman retired from the firm in May 1951. Professor Rutledge, who is chairman of the ASCE Soil Mechanics and Foundations Division, will remain on the Northwestern University staff until June.

Philip C. Rutledge

David Anderson, member of the London civil engineering firm of Mott, Hay &

Anderson, was recently knighted by King George VI. Sir David has just attained life membership in ASCE.

Haywood G. Dewey, executive officer of the 32nd Engineer Construction Group, stationed in Korea, has been promoted from the rank of major to that of lieutenant colonel. In World War II Colonel Dewey served as assistant to the Division Engineer, Corps of Engineers, Lower Mississippi Valley Division. At the time of his recall to active duty in August 1950, he was hydraulic engineer in the Jackson, Miss., suboffice of the U.S. Waterways Experiment Station, and secretary-treasurer of the Mid-South Section of the Society and president of its Jackson Branch.

Colonel Dewey

George M. Foster, of East Lansing, Mich., has been appointed chief deputy commissioner of the Michigan State Highway Department. Except for a ten-year period in private practice, Mr. Foster has been with the department since 1922—most recently as bridge engineer.

George M. Tapley is now hydroelectric engineer for Knappen-Tippetts-Abbett-McCarthy, New York engineers. He will be stationed in Rangoon, Burma, in charge of making an economic and technical survey of the resources of the country. Until recently Mr. Tapley was chief of the Engineering Division of the Alaska Road Division at Juneau, Alaska.

Harland Bartholomew, head of Harland Bartholomew and Associates, city planners, landscape architects, and civil engineers of St. Louis, Mo., announces the opening of a Southeastern office at 101 Marietta Street Building, Atlanta, Ga. The new office will be under the direction of **Charles P. Clayton.**

William H. Correale is now with Moran, Proctor, Freeman & Mueser, of New York City, as resident engineer on construction of a $4,000,000 industrial plant at Archbald, Pa. Mr. Correale was formerly project engineer for Knappen-Tippetts-Abbett-McCarthy, New York engineers.

Walter H. Price has been named head of the Bureau of Reclamation's Engineering Laboratories at Denver, Colo. On the staff of the Bureau of Reclamation since 1930, Mr. Price has recently been serving as head of the Materials Laboratories. In his new capacity he succeeds **Robert F. Blanks,** who resigned to accept the position of vice-president for Great Western Aggregates, Inc., of Denver.

Robert G. Macdonald, lieutenant colonel, Corps of Engineers, has been made post engineer at the Utah General Depot, Ogden, Utah.

Perry L. Grammer is now civil engineer

(*Continued on page 142*)

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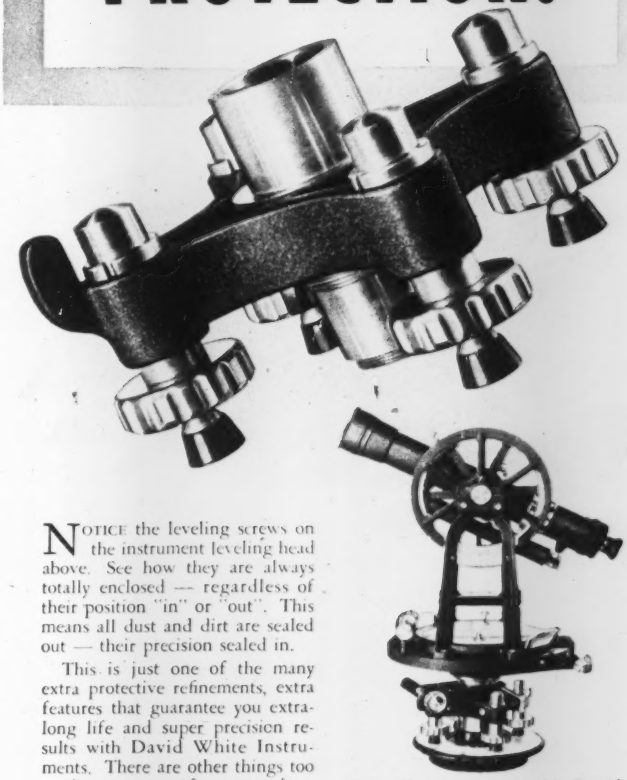

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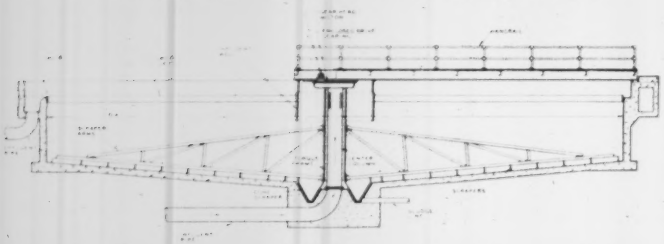
• CIRCULAR CLARIFIERS-THICKENERS



Hardinge Circular Clarifiers for water treatment are available in sizes up to 200' diameter, either center-column or beam-supported for steel, concrete, wood or tile tanks. Bulletin 45-C-37.
Hardinge Thickeners for removal of fine suspended solids from supply water, and sewage, are similar to the Clarifiers but of heavier construction. "Auto-Raise" mechanism prevents scraper breakage. Bulletin 31-D-37.

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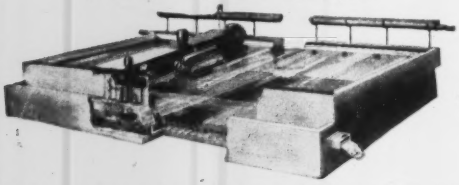
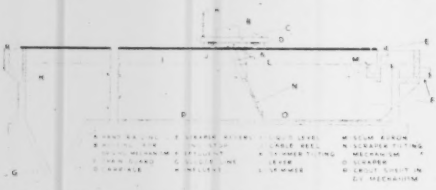


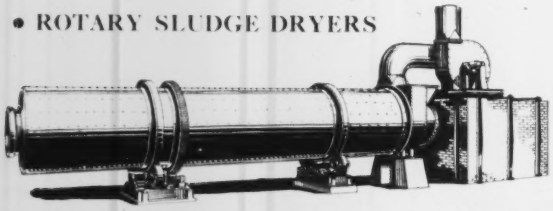
For high removal of non-settling or slow-settling suspended matter. Self-cleaning sand bed. No shutdown necessary for backwashing. Bulletin 46-37.

• RECTANGULAR CLARIFIERS



Especially suited for limited spaces or where sludge delivery is desired at one end of the tank. Bulletin 45-C-37.

• ROTARY SLUDGE DRYERS



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News of Engineers

(*Continued from page 141*)

and party chief with the Tennessee Valley Authority at Boone Dam near Johnson City, Tenn.

Edward Lindskog, lieutenant, U.S. Army Air Force, has been assigned as an inspector at Tullahoma, Tenn. He was formerly in the Los Angeles Department of Building and Safety.

Burnside R. Value, of the New York City civil engineering firm of Seelye, Value & Stevenson, was recently elected vice-president of the New York Association of Consulting Engineers.

Robert K. Sawyer has been appointed managing director in the new Philadelphia city administration by the mayor-elect. His new duties will include appointing heads for many of the city departments. In filling posts requiring high civil engineering experience, he will have the advice of a committee of Philadelphia Section members headed by **Thomas Buckley.** Colonel Sawyer was previously executive director of the Greater Philadelphia Movement.

Curtis Chester Harlin, Jr., has been named Humble Oil & Refining Company fellow in civil engineering for the 1951-1952 term at the Agricultural and Mechanical College of Texas. The fellowship is one of several offered by the company to promote advanced study in engineering and science. Mr. Harlin received his B.S. degree in civil engineering from Texas A & M in February 1950, and later was employed in the Engineering Department of the City of Abilene. As a student he was active in the Society's Student Chapter.

Curtis C. Harlin, Jr.

Theodor von Karman, director of the scientific advisory board of the U.S. Air Force and honorary professor of mechanical engineering at Columbia University, has been given a Fulbright Award to lecture in fluid mechanics at the University of Paris during the current academic year. An internationally known authority in the field of aerodynamics, Dr. von Karman was made an Honorary Member of ASCE in January 1950.

H. L. Hudson is now chief field supervisor for the Detroit firm of Giffels & Vallet, Inc., at Oak Ridge, Tenn.

Thomas K. Breitfuss has become connected with the American Concrete Pipe Association, Chicago, Ill., as assistant to **Howard F. Peckworth,** managing director. A veteran of World War II, with overseas duty with the 12th Armored Division in Europe, Mr. Breitfuss was until recently in the Sewage Engineering Department of the Chicago Pump Company. He is junior treasurer of the Illinois Section of the Society.

(*Continued on page 144*)

JACK AMMANN PHOTOGRAMMETRIC ENGINEERS

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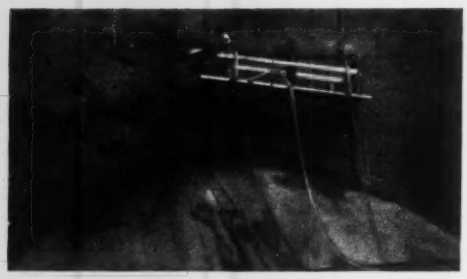

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News of Engineers

(*Continued from page 142*)

John D. Fitch has accepted engagement with Ebasco Services Incorporated, of New York, as a consulting engineering specialist on economic analyses, investigations, and engineering problems connected with financing. For the past nine years Mr. Fitch has been principal engineer and chief of the Engineering Division for the Export Import Bank, Washington, D.C. In 1947 he served on a temporary assignment as the engineering member of the American Economic Mission to Greece.

John D. Fitch

Dean Beaumont, formerly junior civil engineer for the State Division of Water Resources, at Sacramento, Calif., has become assistant civil engineer in the survey section of the State Division of Architecture.

Sidney N. Weniger and **Thomas J. Sette** announce the formation of a construction corporation under the name of Weniger & Sette. Headquarters of the organization, which will specialize in engineering, contracting, and concrete construction, will be East Williston, N.Y. Mr. Sette was formerly with the Rizzi Construction Co., Inc., of New York City.

Raymond E. Layton, previously senior civil engineer for the East Bay Municipal Utility District at Oakland, Calif., has established a consulting practice at Castro Valley, Calif.

Joseph D. Lewin has resigned as engineer for the New York City Board of Water Supply to accept a position with Knappen-Tippetts-Abbett-McCarthy, of New York, in Athens, Greece, where he will complete designs for a Marshall Plan irrigation project for the Greek government.

Gordon Long, previously senior engineer for the California State Division of Highways and Water Resources at Sacramento, has been recalled to active duty as a major in the Corps of Engineers, with headquarters in Sacramento.

Roger R. Robertson has retired as engineer for the U.S. Bureau of Reclamation after 37 years of service. He has been with the Bureau since 1914—for the past eleven years on the Columbia Basin Project at Ephrata, Wash. In his early career Mr. Robertson was engaged on power development for the Colorado Power Co., in Colorado, and for Stone & Webster, of Boston, on the Big Creek development in California.

Roger R. Robertson

(*Continued on page 146*)

Contract 50—Section 7
New Jersey Turnpike Authority

Our job included construction of a bridge crossing the yard and main line tracks of the West Shore Division of the New York Central Railroad and the New York Susquehanna and Western Railroad in the vicinity of Ridgefield, New Jersey.

The structure, consisting of 36″ WF beams supported on concrete piers of the "Tombstone" type, is approximately 1100′ in length; the piers are founded upon cast-in-place concrete piles ranging in length from 100 to 165′, driven by the Raymond Concrete Pile Company. Work was commenced in October 1950.

The accuracy with which the work was planned by the Designing Engineers, is worthy of comment and is evidenced by the close agreement of actual quantities with those expected and set forth in the Invitation for Bids.

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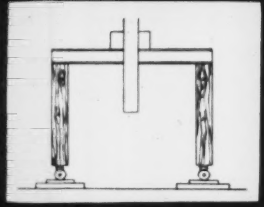

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News of Engineers

(*Continued from page 144*)

Gordon Zander, Tom Waddell, and **Gerry Jones** are assistant state engineers in the Division of Water Resources, at Sacramento, Calif. Mr. Zander has charge of water rights, water quality, and pollution functions; Mr. Waddell of statewide investigations and the Central Valley and Feather River projects; and Mr. Jones of flood control, supervision of dams and "Sacramento-San Joaquin Water Supervision."

Edwin R. Lewis previously with **D. E. Perkins,** architect of Harlan, Ky., has accepted a position with Allen N. Dryden, of Kingsport, Tenn.

Richard A. Haber, chief engineer of the Delaware State Highway Department, Wilmington, Del., has been appointed by the governor to serve on the first Delaware Geological Survey Commission.

J. C. Smith has accepted the position of deputy project manager for the Maxon Construction Company at Oak Ridge, Tenn.

Fred W. Clayton, consulting engineer of Berkeley, Calif., has gone to Rangoon, Burma, to be chief engineer in charge of field design and construction on the Mingaladon Airport for the New York firm of Knappen-Tippetts-Abbett-McCarthy, Engineers.

Leonard L. Huttleston, since 1938 general manager for the New York State Division of Parks, at Syracuse, N.Y., has been named assistant director of the State Division of Parks in Albany. Mr. Huttleston is a past-president of the Ithaca Section of the Society.

William Samuel Denton, captain in the U.S. Air Force, is now assistant professor of air science and tactics at Mississippi State College.

Paul Ricks has joined Bechtel & Co., in San Francisco, Calif., as structural designer. Formerly he was junior civil engineer with the State Department of Public Works, Division of Architecture.

John A. Walls, for the past 27 years president of the Pennsylvania Water and Power Co., at Baltimore, Md., has retired after an engineering career of 42 years. He will be succeeded as president of the Pennsylvania Water and Power Co. by **G. W. Spaulding,** who has been serving the organization for approximately 27 years—since 1947 as executive vice-president.

Nian F. Roberts, of Sacramento, Calif., is on duty as a lieutenant with the Army Corps of Engineers, at Yuma, Ariz.

Eugene Sprout, until recently junior civil engineer for the California State Division of Highways at Sacramento, is now stationed at Scott Air Force Base in Illinois.

G. S. Druhot, who has been topographic engineer with the U.S. Geological Survey, at Sacramento, Calif., has been transferred to the U.S.G.S. office in Washington, D.C., in a similar capacity.

Harold Lansing, formerly junior civil engineer for the California Division of Highways Bridge Department, at Sacramento, has been assigned to the "18th Street to Bryant" project in San Francisco.

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JAMES WALKER CALDWELL, Roanoke, Va.
WILLIAM JOHN CAMPTON, JR., Marysville, Calif.
BEN HUTTON CUNNINGHAM, Savannah, Ga.
ERNEST ARLINGTON FORT, Miami Springs, Fla.
JOHN MORRISON HAGUE, JR., New York, N.Y.
THOMAS REGINALD HILL, Tokyo, Japan.
ALFRED EDGAR HIRSCH, Baltimore, Md.
FREDERICK LAURENCE KLEIN, San Francisco, Calif.
ALBERT ANTHONY KORVES, Syracuse, N.Y.
GILBERT HARRISON MANDEVILLE, Seattle, Wash.
WILLIAM NORMAN McLEOD, Washington, D.C.
LOUIS JACK MONAT, Newark, N.J.
HORST HANS ORBANOWSKI, New York, N.Y.
DAVID HENRY OVERMAN, Columbus, Ohio.
MARIO PALMIERI, Chicago, Ill.
ALSEY CLEMENTS PARKER, Tuscaloosa, Ala.
JOHN JOSEPH SCHNEIDER, Passaic, N.J.
WILLIAM BRUCE THROCKMORTON, Chicago, Ill.
WILSON HENRY WARD, Clarksburg, W.Va.
RAYMOND ALBERT WEBBER, Salem, Oreg.
GEORGE MERTENS WILLIAMS, San Francisco, Calif.

Applying for Associate Member

RICHARD FARRINGTON BERRY, Baltimore, Md.
RAYMOND MAURICE CLOCK, New York, N.Y.
JACK WATSON ECHOLS, Birmingham, Ala.
HARRY CHARLTON ENGLISH, Sheffield, England.
JOSEPH THOMAS GAY, JR., Washington, D.C.
NUGGEHALLI SAMPATH IYENGAR, Hazaribagh, India.
CLINT JAY KEIFER, Chicago, Ill.
WILLIAM RICHARD KIDD, Ocala, Fla.
MICHAEL ANDREW KOLESSAR, Baltimore, Md.
CARLOS FERNANDO LAVIÑAS, Buenos Aires, Argentina.
FRED FRANK LOY, Des Moines, Iowa.
GEORGE EDWARD LULL, JR., Wilmington, Del.
PAUL BRINKER PEECOOK, Los Angeles, Calif.
JOSEPH ELMER PERRY, Tulsa, Okla.
INGVAR SCHOUSHOE, Chicago, Ill.
TAGE KAY SCHRADER, La Paz, Bolivia.
ROGER BROWN STEVENSON, New York, N.Y.
HARRY ELMO WHITE, Clayton, Mo.

Applying for Junior Member

CLIFFORD EINAR ANDERSON, Highwood, Ill.
ARMEN GEORGE AVEDISIAN, Thornton, Ill.
JOHN FRANCIS BRENNAN, Garden City, N.Y.
EDWARD HENRY BRYAN, Madison, Wis.
CHARLES JOHN BURM, Ann Arbor, Mich.
EDWARD FRANCIS BUTLER, Helena, Mont.
LANE FOUGHT COLE, La Mesa, Calif.
GORDON BENNETT DALRYMPLE, Chamblee, Ga.
RAY LOCKE DAY, Bastrop, La.
SANTOS I. DE LA CRUZ-VELAZQUEZ, Manati, Puerto Rico.
WILLIAM BRINK FAULKNER, Tulsa, Okla.
JAMES MONROE GERE, Troy, N.Y.
MOHAMED FAHMY GHANEM, Urbana, Ill.
AUGUST RUDOLF GRANIS, Chicago, Ill.
HAROLD THOMISON HOGUE, Knoxville, Tenn.
LEROY ERNEST HOLMES, Lake City, Utah.
JOHN OWENS JACKSON, Knoxville, Tenn.
ROBERT THOMAS JOUGHIN, Casablanca, French Morocco.
GUY NELSON KEITH, Oklahoma City, Okla.
PETER GEORGE KELLEY, West Union, Iowa.
ABDEL WAHAB A. KIRAH, Cairo, Egypt.
CALVIN ARTHUR KNOKE, Columbus Falls, Mont.
ROBERT BURNEY LONG, JR., Miami, Fla.
JOSE MARIA MARTIN MENDILUCE, Madrid, Spain.
TEISUJI MOTAI, Troy, N.Y.
CHARLES ROY NAGEL, Wauwatosa, Wis.
BEVILLE SLONE OUTLAW, JR., Gainesville, Fla.
RALPH WILLIAM PETERSON, Hammond, Ind.
ERNEST HENRY ROGERS, Seattle, Wash.
EDWARD CHARLES RUBIS, Fort Belvoir, Va.
ALY ABDEL AZIZ SABRY, Urbana, Ill.
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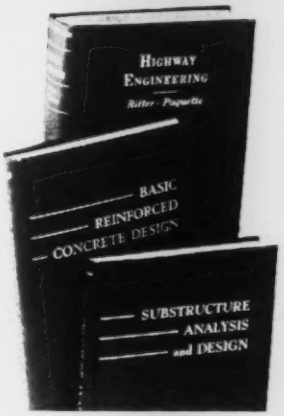
[Applications for Junior membership from ASCE Student Chapters are not listed.]

Practical books for the HIGHWAY ENGINEER



HIGHWAY ENGINEERING
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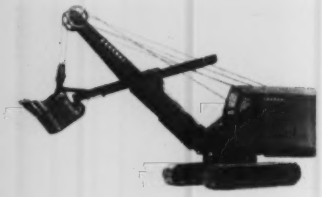
THE MODEL 320, ¾ cu yd excavator and material handler, is a compact sturdy machine which is economical to operate, simple to maintain, and safer to use. The crawler base, machinery side frames and the deck, are made of castings and rolled structural steel shapes, used separately or in combination to obtain the maximum advantage of each type of material and



Model 320

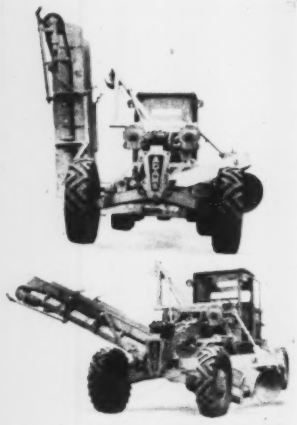
construction. Machinery mounted on the superstructure is placed well back on the deck, thus giving an unusual stability and increased lifting capacity, with a minimum amount of dead counterweight necessary. Ground bearing pressures are low. The Model 320 is fully convertible to shovel, clamshell, crane, pile driver, dragline, and hoe work, in the field with a minimum of effort. The standard shovel boom length is 18 ft 8 in. with a dipper handle of 15 ft 3 in. effective length. Standard crane boom length is 35 ft. Standard length of crawler is 11 ft 4 in., with 20 in., 25 in., or 30 in. treads available. It is manually controlled. Special attention has been given in design to present a smooth and quiet running machine, with safety a prime factor. Another feature is the accessibility of working parts, and the ease of their removal without disturbing other parts. **The General Excavator Company, Marion, Ohio.**

Fast Setting Cement

ANCHOR BOLTS FOR permanently fastening machinery, hand rails, seats, or equipment of any type to concrete, can now be set easily, quickly and with complete safety by using Por-Rok quick setting cement. It successfully replaces critical lead and sulphur for most bolt-setting operations. Applied cold, there is no heating hazard and the speed with which it forms a permanent weld-joint is amazing. Por-Rok is self-bonding, self-leveling, oil resistant, and will not shrink. It has the remarkable compression strength of 4500 lbs psi, verified by an independent testing laboratory. **The Hallemite Manufacturing Company, 2446 W. 25th St., Cleveland 13, Ohio.**

Elevating Grader

AN ELEVATING GRADER attachment, with a hinged carrier to facilitate movement from job to job, has been announced. The unit is called Elegrader and it is designed to work on Adams models 550 and 610 motor graders. The exclusive hinged carrier design rules out time-taking and troublesome dismantling to allow highway travel, and clearance is no problem for oncoming traffic, through narrow gates and underpasses, over narrow bridges or loading onto other vehicles for long hauls. The Elegrader has been carefully designed to permit maximum visibility for the operator both in normal operating position or with the carrier raised to traveling position. Less than fifteen minutes is required to raise the hinged carrier to traveling position, and when this has been done, the elegrader has the same center of gravity as the motor grader alone. The carrier is equipped with a 36 in. trough type belt which is an innovation in elevating grader design and has equal capacity to a 48 in. conventional flat type belt. All troughing rollers are mounted on self-lubricated, permanently sealed ball bear-

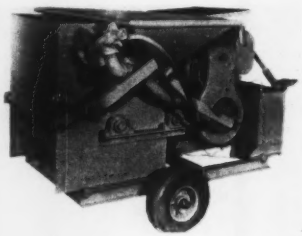


Elegrader

ings which do not require any servicing, and all other moving parts are mounted on either ball or roller bearings. Another major feature is ease of mounting the attachment to the motor grader. No welding, cutting or major alterations to the grader are necessary. Precision made interlocking steel wedge plated reinforce the hinge on the carrier, assuring a rigid, solid stiffness in either working or traveling position. **Williams & Reisser Co., P. O. Box 1126, 23rd and Hickory Sts., Omaha 1, Nebr.**

Bituminous Mixer

THE MODEL HTD-S portable bituminous mixer of the batch type, suitable for making "hot," "heated," or "cold" bituminous mixtures has been announced. Capacity is 3 cu ft per batch; heat is supplied by 2 oil burning torches; hot mixtures may be heated up to 300 deg F; cold mixtures are prepared in the conventional manner. Complete working weight

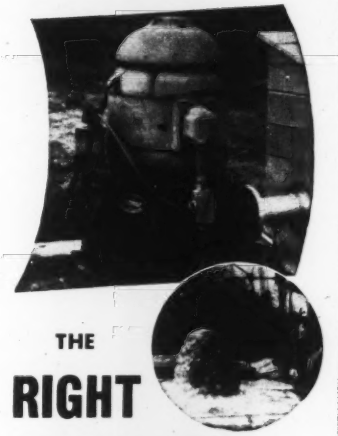


Model HTD-S Mixer

is 1200 lbs, power is supplied by 6 hp air-cooled engine, trailer mounted on two rubber tired wheels. The mixer can be used with limestone, slag, trap rock, gravel or sand, and emulsified asphalts, cutbacks, tars or asphaltic cement to produce asphaltic concrete, sheet asphalt, sand asphalt or mastic asphalt mixtures. Permanent, hot patches may be placed in zero weather, and premixed or stock pile mixtures may be run through the mixer, heated and placed on the spot. **K. E. McConnaughay, 545 Fifth Avenue, New York 17, N. Y.**

Precast Buildings

PRECAST SHELTERS FOR delicate equipment, valve or guard houses, etc., are now being supplied as a single packaged unit. They are manufactured of Thermo-Con, a light weight cellular concrete, and arrive at the site complete in every respect. The shockproof quality of the structure permits transportation on truck, rail, or barge. The high insulating value of the building makes automatic control of temperature a minor problem. As the shelter is made in one pour, cracks are non-existant and the walls are completely waterproof. The wiring is in concealed conduits and designed for particular needs. The structures are made in any desired size and may be constructed with a telescoping exterior to house auxiliary units. Mobile construction equipment, makes possible, in sizable contracts, the fabrication of the buildings at or near the final location. **Thermo-Con Texas Corp., P. O. Box 12188, Houston 17, Tex.**



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Equipment, Materials & Methods (Continued)

Portable Hydraulic Cutter

THE RECENT DISMANTLING of an explosion-wrecked plant in the Chicago area presented a serious problem in the removal of bent and twisted $^3/_4$ in. reinforcing rods, until a portable hydraulic cutter was brought to the job. Due to the presence of inflammable fumes in the plant, a cutting torch could not be used. The only alternative method of cutting was with a hack saw, which would have been slow and expensive. The hydraulic cutter, a relatively new tool, was a Model 20-B Guillotine. As this unit is light in weight, readily portable, and contains no components capable of igniting combustible vapors, it was ideal for job. The cutting head weighs only $28^1/_2$ lbs, permitting the operator to crawl with ease throughout the structure to reach the exposed rods. While the Guillotine is available with power-operated hydraulic pumps, a hand-actuated hydraulic pump supplying 45,000 lbs of thrust to the cutter was selected as the best for this particular job. The actual cutting operation took an average of only 8 to 10 sec. **Manco Manufacturing Co., Bradley, Ill.**

Scraper

WITH OVER 40 PERCENT more struck capacity than previous models, the "Cat" No. 90 scraper is designed to increase earthmoving production when used with DS tractor power. Struck capacity of 21.2 cu yds can be increased to 25.5 cu yds with the addition of top extensions or side boards. Likewise, heaped capacity is 27 cu yds, or 31 cu yds with the available

No. 90

sideboards. The scraper moves dirt with the aid of a hard surfaced, reversible cutting edge. Material is carried in a flat, double-bottom bowl of high tensile steel. Operation is by means of a cable control unit, which can be mounted on the rear of the tractor to provide for positive loading and ejection. Tapered roller bearings are installed at each axle. The scraper uses two 24.00-29 front tires and two 27.00-33 rear tires, all four of 24-ply rating. When loaded, the scraper distributes 60 percent of the weight on the rear tires. **Caterpillar Tractor Company, Peoria 8, Ill.**

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Equipment, Materials & Methods (Continued)

Heavy Duty Shovel

A 10-CU YD MINING and quarry type machine described as the world's largest, most powerful shovel on two crawlers is being announced. It is the Marion 191-M for which many impressive performance features are claimed, including the following: A 10 cu yd heavy duty shovel with small machine cycle time; more strength and more power, in terms of digging effort and speed, per cu yd of capacity; greater travel speed and maneuverability than

Model 191-M

most small machines; loads trucks of the 50 ton class in three or four passes; heavily built throughout for the toughest digging jobs; Ward Leonard control; "Amplidyne" or "Rototrol" application of electric power; and production potential of over half a million yards per month. The lower frame of the 191-M is formed of heavy steel plate welded into a deep bulkhead structure for strength and rigidity. The upper frame is a deep welded structure with machinery supports welded integral with the frame. Two matching 187½ hp 600 line motors, with blowers, operate the hoist machinery and, through the use of clutches, drive the propel mechanism. Twin swing motors of 62½ hp are also equipped with blowers. Another 62½ hp motor mounted on the boom provides power for crowding and crowd retract. **Marion Power Shovel Company, Marion, Ohio.**

Street Markers

THE TENTE PLASTIC MARKERS are quick and easy to apply to any type of street surface and never need further attention once they are down, during the life of the marker which is four to six years. The Dur-O-Line marker is a simple plastic saucer shaped disc, 4½ in. in diameter. They are usually spaced about 2 ft apart to make a well defined traffic lane. The marker will withstand 63,000 lbs pressure, which is well above the maximum load limits, consequently the problem of breakage is almost negligible. They are solid in color all the way through and are available in traffic yellow or dead white. Wear cannot dull their original brightness. Two average workers can lay 100 street markers per hour and cars can run over them as soon as they are down. **Traffic Safety Supply Company, N. E. Sandy Blvd. at 27th, Portland 12, Ore.**

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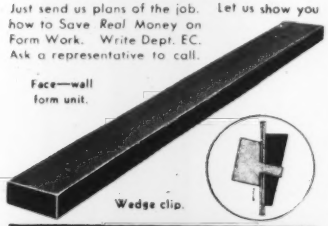

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Equipment, Materials & Methods (Continued)

Weld-on Plate

SCARCITY OF STEEL and other metals continues to stimulate a campaign of "Machine Care for Longer Wear" by Caterpillar Tractor Co., producing new techniques to keep veteran machines in operation. Most recent contribution by Caterpillar is the weld-on plate for resurfacing track links worn too deeply for the successful use of weld overlays. Applied to D7 and D8 tractors, the method makes it possible to resurface track links worn in excess of $\frac{3}{8}$ in. Track type tractors roll on the steel rails formed by the track links. Induction hardening is applied to the rail surfaces, so that wear normally appears only after thousands of hours of usage. The weld overlay is a method developed earlier to restore the surface of worn parts, and it is recommended that this method be used as soon as track links are worn through the original surface hardness of about $\frac{1}{8}$ in. Successful overlays are possible up to three thicknesses, or about $\frac{3}{8}$ in. Beyond this point, track link plates are estimated to be more economical for the D7 and D8. Made of hardened and tempered steel, these plates resist abrasion and shock. **Caterpillar Tractor Co., Peoria 8, Ill.**

High Speed Paver

DESIGNED WITH ULTRA HIGH speed operating cycles, the 34E dual drum paver is manufactured to meet modern paving conditions. Typical of the speed claimed for the Model WP paver is a boom bucket travel rate of 256 fpm. The power loader

34-E Dual Drum Paver

skip requires only $6\frac{1}{2}$ sec to travel from the ground to discharge position of 56 deg low slope. Transfer from the first to the second mixing compartment also requires about $6\frac{1}{2}$ sec depending upon consistency of the concrete. Discharge into the boom bucket is another $6\frac{1}{2}$ sec operation. Boom swing is a full 171 deg. The Model WP Worthington-Ransome paver retains the exclusive hydraulic bucket, permitting complete control of rate of concrete discharge under all conditions. Increased braking area, more efficient boom raising and lowering machinery, a redesigned drum, and entirely new crawlers and frames are other features of the machine. **The Construction Equipment Div., Worthington Pump and Machinery Corporation, Dunellen, N. J.**

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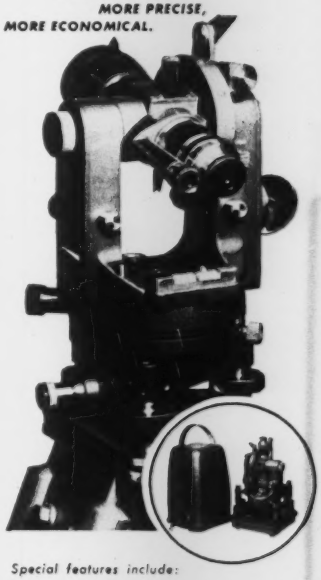

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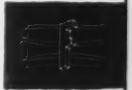

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Equipment, Materials & Methods (Continued)

Scraper

AMONG THE UNIQUE features of the McGee scraper is the ability to backfill, scarify, grade (both rough and finish) and a thousand and one scraping uses for school yards, playgrounds, airports, streets, driveways, etc. The scraper is the only one with cradle action and a revolutionary

Hydraulic Control

hydraulic upper-link control. This exclusive, advanced control is the first time hydraulic control of scraping angle has ever been applied to a scraper. The operator, with but a touch of the control valve adjusts the tilt. The tilt can be changed for scraping, back-filling or scarcifying . . . all without dismounting from the tractor. With a bucket capacity of approximately ¾ yard and a cutting and back filling blade 5 ft 6 in. wide, the total weight of the McGee scraper is 450 lbs. **The Tractor Sales Corp., 1409 Santa Fe Ave., Los Angeles 21, Calif.**

Transformer Welder

THE AIRCO MODEL MCM 200 ampere transformer welder is designed for general maintenance and production welding. It is a rugged unit with easy-to-operate controls and is built for long, dependable service in garages, job shops and industrial plants. The MCM has a full 200 ampere, 50 percent duty cycle, NEMA ratmg. Four variations are available—220 volt or a 220-440-550 volt unit, each with or without power factor correction. Two open circuit voltages are provided—80 volts on the low range and 55 volts on the high range. This combines easy arc starting with a lower KVA demand load and primary ampere current. Safe, dependable operation is assured by complete, up-to-the-minute insulation throughout. The easy-to-read current indicator affords quick adjustment of welding current. Maintenance cost is low because there are no moving parts, and each part is designed for long life even under the toughest operating conditions. **Air Reduction Sales Co., 60 East 42nd St., New York 17, N.Y.**

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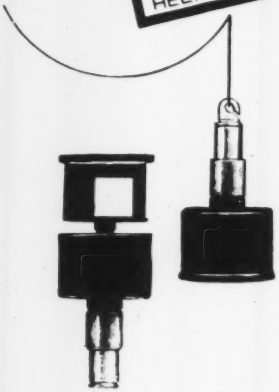

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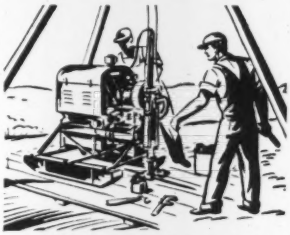

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Literature Available

VERTICAL PROPELLER PUMPS—Bulletin W-314-B2 on vertical propeller pumps for flood control, drainage, irrigation and similar low head services is announced. It contains cross section drawings, dimensions and a discussion of recommended clearances for the pumps. A request on company letterhead will bring you a copy of this bulletin. **Worthington Pump and Machinery Corporation, Harrison, N.J.**

WALL FORMS—An 8-page revised directions booklet on wall forms is available. Complete details are given for the erection of Symons forms including panel alignment, stripping, spacing of ties, safe work load for ties and pressure per square foot that the forms will stand. Complete illustrated information on the many accessories that are available for use with the forms is also included. **Symons Clamp & Mfg. Co., 4249 Diversey Ave., Chicago 39, Ill.**

EXCAVATOR CATALOG—A sales catalog describes the latest advancements made on the Koehring Model 304 excavator and its attachments. The attractive two-color booklet contains 117 illustrations and drawings that depict the story of design, construction, work capacity and wide application of the heavy-duty excavator. **Koehring Company, Milwaukee 16, Wis.**

PNEUMATIC TIRED ROLLERS—A bulletin on pneumatic tired rollers is announced. Features such as oscillating axles, staggered wheels and underslung chassis are listed, and specifications, diagrams and front and rear views of the rollers are included. **Tampo Manufacturing Co., 1146 W. Laurel St., San Antonio, Tex.**

POWER PLANT COAL HANDLING—A 44-page book, No. 2410, on coal and ash handling equipment for power plants, is now available for distribution. It contains helpful layout drawings and interesting photographs of actual installations. It is a book of ideas and suggestions for solving the coal and ash handling problems of today's power plants. There are sections in the book on unloading coal, auxiliary unloading, coal storage and reclaiming, crushers, transporting and distributing equipment, ash handling, and water intake screens. **Link-Belt Company, 307 N. Michigan Ave., Chicago 1, Ill.**

MOTOR-DRIVEN CONTROLLED VOLUME PUMPS—A 24-page, two-color, illustrated bulletin on motor-driven controlled volume pumps has been published. Bulletin No. 251, will be of interest to anyone faced with the need of pumping practically any liquid, from heavy viscous liquids to light solvents, solids in suspension, abrasive slurries, hot or cold liquids, liquefied gases, and other materials. Capacity pressure selection tables are included to help users select the right pump for their particular application. **Milton Roy Company, 1300 East Mermaid Lane, Philadelphia 18, Pa.**

Driving sand drains for sub-surface stability for projects such as the New Jersey Turnpike is just one phase of Mac Arthur's all-around activity. Also available for foundation work are Mac Arthur cased, compressed, pedestal, composite, wood, and the well-known Steel Saver piles. Have your engineers ask about them for your next foundation project.

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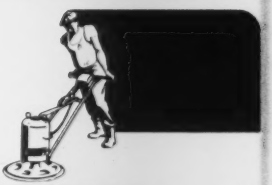

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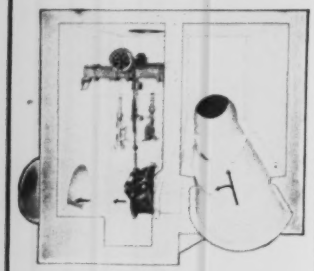

Fig. B-19

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HEAVY DUTY MACHINE. A two-page catalog in color has been published on the Bushwacker, a heavy-duty, tractor-mounted machine for low-cost land-clearing operation. A series of on-the-job action photographs illustrates the principle of operation, rate of production and final results at a typical job site. Complete specifications and operating data are also included. **American Steel Dredge Co., Inc., Fort Wayne 1, Ind.**

GRIT REMOVER. A 24-page, two-color bulletin, No. 6411, describes the Dorr Detritor in detail covering the several different types available, with drawings, sizes, capacities and operating descriptions. Photographs of numerous installations are included as well as operating results from 32 Detritors in the field. **The Dorr Company, Barry Place, Stamford, Conn.**

LAYKOLD FIBRECOAT. A 4-page brochure in three colors, giving detailed application data and listing outstanding uses of Laykold Fibre, a weatherproof mineral-armored asphalt, has just been issued. It includes specifications, application data, approximate costs, and illustrated, detailed information regarding equipment used in applying the product. **American Bitumuls & Asphalt Company, 200 Bush St., San Francisco 4, Calif.**

WATERWORKS GATE VALVES. A complete line of iron-body gate valves for municipal water supply systems is described and illustrated in Bulletin 106. It covers AWWA specifications, operating mechanism, methods of operation, special features and end connections available, plus full dimensional data for sizes 3 in. to 48 in. **The Kennedy Valve Mfg. Co., Elmira, N. Y.**

MATHEMATICAL TABLES. A revised loose leaf data book containing mathematical tables and formulae needed to solve problems in arithmetic, geometry, algebra, trigonometry, analytical geometry and calculus is announced. The material is conveniently arranged in six thumb-indexed sections for ready reference. It has 176 pages, a 2 pin cover, and costs $1.50. Another catalog which gives over 2,000 listings of technical data books in convenient pocket size is free. **Lefax Publishers, Philadelphia 7, Pa.**

MOTOR SCRAPER. A 16-page, two-color catalog describing the Model TS300 motor scraper, a high speed, rubber-tired, self-propelled earthmover, has just been released. The copy and photographs explain the construction features of the motor scraper in full detail. Individual photographs of the various component parts are included. The center spread is devoted to a large model shot of the motor scraper and complete machine specifications. Ask for form No. A-1285. **Advertising Dept., LaPlant-Choate Mfg. Co., Inc., Cedar Rapids, Iowa.**

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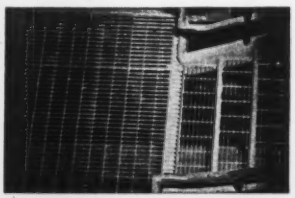

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Summarized in Earlier Issues

87. Sewage Reclamation by Spreading Basin Infiltration, by Ralph Stone and William F. Garber.

88. Experimental Study of Water Flow in Annular Pipes, by W. M. Owen.

89. Deflections in Gridworks and Slabs, by Walter W. Ewell, Shigeo Okubo, and Joel I. Abrams.

D-30. Discussion of Paper, **Economic effects of Reservoir Sedimentation,** by William E. Corfitzen.

D-40. Discussion of Paper, **Construction Technique of Passing Floods Over Earth Dams** by Andrew Weiss.

D-34. Discussion of Paper, **Lateral Buckling of Eccentrically Loaded I-Section Columns,** by H. N. Hill and J. W. Clark.

D-38. Discussion of Paper, **Hydrology of Mexico,** by Andres Garcia Quinteto.

D-17. Discussion of Paper, **Origin and Significance of Openwork Gravel,** by Allen S. Cary.

D-33. Discussion of Paper, **Strength of I-Beams in Combined Bending and Torsion,** by Basil Sourochnikoff.

90. Consumptive Use of Water by Forest and Range Vegetation, by L. R. Rich.

91. Consumptive Use of Water, by Harry F. Blaney.

92. Experimental Investigation of Fire Monitors and Nozzles, by Hunter Rouse, J. W. Howe, and D. E. Metzler.

93. Aircraft Design as Related to Airport Standards, by Milton W. Arnold.

94. Friendship International Airport, by Benjamin Everett Beavin.

95. Directional Requirements for Airport Runways, by Ralph H. Burke and Harry Otis Wright, Jr.

96. Surface Curves for Steady Nonuniform Flow, by Robert B. Jansen.

D-36. Discussion of Paper, **Impossibility of Performance in Contracts for Engineering and Construction,** by Robert F. Borg.

D-39. Discussion of Paper, **Practical Design of Solid-Barrel Reinforced-Concrete Skew Structures,** by Bernard L. Weiner.

D-42. Discussion of Paper, **Wind-Load Standards in Europe,** by John W. T. Van Erp.

D-43. Discussion of Paper, **Settlement Correction at La Guardia Field,** by John M. Kyle.

D-44. Discussion of Paper, **The Problem of Wave Action on Earth Slopes,** by Martin A. Mason.

Third Notice

97. Consumptive Use in the Rio Grande Basin, by Robert L. Lowry.

98. Consumptive Use of Water on Irrigated Land, by Wayne D. Criddle.

99. Consumptive Use in Municipal and Industrial Areas, by George B. Gleason.

100. Forced Vibrations of Continuous Beams, by Edward Saibel and Elio D'Appolonia.

101. Application of Highway Capacity Research, by J. P. Buckley.

102. Utilization of Ground Water in California, by T. Russel Simpson.

103. Pile Foundations for Large Towers on Permafrost, by L. A. Nees.

104. Redesign of Major Airport Terminals, by Herbert H. Howell.

105. Principles of Highway Capacity Research, by O. K. Normann.

D-37. Discussion of Paper, **Design of Prestressed Tanks,** by J. M. Crom.

D-47. Discussion of Paper, **Operation and Maintenance of Irrigation Systems,** by Raymond A. Hill.

Second Notice

106. Analysis of Ground Water Lowering Adjacent to Open Water, by Stuart B. Avery, Jr. A theoretical analysis of ground water lowering adjacent to open water is presented. The formulas and graphs included permit rapid computation of pumping rates required for various drawdowns and arrangement of wells. Computed values are compared to those observed on an actual well installations. (Available January 1.)

107. Characteristics of the Solitary Wave, by James W. Daily and Samuel C. Stephan, Jr. The solitary wave—with a single elevation and a constant velocity—is important because it occurs in a number of natural circumstances with sufficient consistency to make it useful in the prediction of wave action for design purposes. The authors explore the accuracy of wave theory in terms of available test data and conclude that they verify the Boussinesq-Rayleigh celevity equation reasonably well. (Available January 1.)

108. Control of Embankment Material by Laboratory Testing, by F. C. Walker and W. G. Holtz. The behavior of soils in earth dams during construction and subsequently is compared with properties determined by laboratory tests. Procedures are given for evaluating the effect of coarse-grained particles on the behavior of impervious soils, and a method for controlling and placing pervious soils is described. The development and control of pore

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pressures during construction are explained. Methods for determining pore pressures to be expected for given placement conditions are described, and field control procedures to restrict pore pressures are defined. Examples illustrate the effect of good construction control. (Available January 1.)

109. Final Foundation Treatment at Hoover Dam, by A. Warren Simonds. The unprecedented height of Hoover Dam with the extremely high head of water against the foundations and abutments created problems in design that were not subject to exact analysis. The foundation treatment was based on experience and precedent. Pressure grouting and drainage were relied upon to produce an adequate foundation. When the reservoir filled, leaks developed at unexpected places, excessive flows of water were discharged from certain foundation drains, and the uplift pressure on the base of the dam increased until its value exceeded that used in the design assumptions. This paper describes the corrective measures necessary to make the structural conditions agree with the original design assumptions. (Available January 1.)

110. Review of Flood Frequency Methods, final report of the Subcommittee of the ASCE Joint Division Committee on Floods. Factors that affect the accuracy of flood-frequency prediction are presented, and the limitations of the various known approaches to the problem are recorded. The report contains a description of the several methods in use for construction flood frequency curves. (Available January 1.)

111. Research in Water Spreading, by Dean C. Mucklel. It has recently been proposed to recharge ground water supplies by spreading on soils of fine texture. This paper describes the problems involved in obtaining satisfactory infiltration rates and research done in altering the infiltration rate curves as found on undisturbed soils. Results of tests made on small ponds are reported under one of five general types of treatment (1) chemical, (2) mechanical, (3) operational procedures, (4) vegetative, and (5) addition of organic matter. Infiltration rates were increased materially by the addition of organic matter. (Available January 1.)

D-49. Discussion of Paper, **Large Hyperbolic Functions Computed by Fission,** by F. T. Llewellyn. Proceedings-Separate No. 59 (December 1950) explained a simple application of hyperbolic sines and cosines for the solution of structural problems by slide-rule, which is more precise and more rapid than that of interpolation by proportional parts. Discussers are: John Sherman, K. L. Cooper, and F. T. Llewellyn. (Available January 1.)

D-54. Discussion of Paper, **Truss Deflections by the Coordinate Method,** by Kuang-Han Chu. In Proceedings-Separate No. 54 (January 1951) Mr. Chu offered for discussion a simplified method that is an algebraic equivalent of the Willnot-Mohr diagram. It can be carried to any degree of accuracy. Those who discussed were: L. C. Maugh, and Kuang-Han Chu. (Available January 1.)

D-61. Discussion of Paper, **Structural Damping in Suspension Bridges,** by the late Friedrich Bleich and L. W. Teller. A caretul correlation between theory and experimental data on frictional damping of structural members. (Proceedings-Separate No. 61, March 1951.) R. K. Bernhard, George S. Vincent, F. B. Farquharson, Arne Selberg, and the late Friedrich Bleich and L. W. Teller discussed this paper. (Available January 1.)

First Notice

112. Diversions from Alluvial Streams, by C. P. Lindner. The hydraulic effects of diversions from alluvial streams and the withdrawal of bed load are rather comprehensively discussed. Less known hydraulic influences are described. Reasons for the withdrawal of bed load in amounts differing from the quantities of water diverted are given. The effects of diversion on the channels involved and the long-time trends that may be expected after diversion are explained. Suggestions are made for the siting of a diversion in order that desired results may best be accomplished. (Available February 1.)

113. Wave Forces on Breakwaters, by Robert Y. Hudson. The two principal types of breakwaters are vertical-wall structures and those with sloping faces constructed of rubble. This paper reviews: (a) the existing wave-pressure theories for determining the magnitude and distribution of wave forces on vertical walls; (b) the particular wave theories upon which most of the wave-pressure theories are based; and (c) theories for determining the weight of cap rock and required slope of rubble-mound breakwaters. The different theories are compared and the best are selected for use. Also, the results of the better theories are compared with experimental data and a suggested outline of future investigations considered necessary to insure safe and economical breakwater design is presented. (Available February 1.)

114. Utilization of Underground Storage Reservoirs, by Harvey O. Banks. To meet the ever-increasing demands for additional water supplies at reasonable cost, planned development and utilization of the immense potential storage capacity available in groundwater basins will be necessary since few surface reservoir sites of large capacity, high yield and low cost remain undeveloped. The paper discusses ground-water hydrology in relation to such development and utilization and describes some of the problems connected therewith. A proposed project for Ventura County, California, utilizing underground reservoirs for cyclic storage with relatively small surface reservoirs operated as regulatory storage to increase recharge to the ground water basins is described. As compared to utilization of surface storage alone, large savings are indicated. (Available February 1.)

D-51. Discussion of Paper, **Laterally Loaded Plane Structures and Structures Curved in Space,** by Frank Baron and James P. Michalos (January 1951). Procedures for analyzing structures curved in space and loaded in space and loaded in any direction. Discussers: Uku Müllersdorf, Maurice Barron, and Frank Baron and James P. Michalos. (Available February 1.)

D-57. Discussion of Paper, **Design of Irrigation Systems,** by W. H. Nalder (February 1951). The principal features of three multiple-purpose projects, emphasizing the planning and design considerations in the development of irrigation features. Discussers: Ahmed Shukry, and W. H. Nalder. (Available February 1.)

D-60. Discussion of Paper, **Surveying and Mapping Requirements for Modern City Planning,** by Charles A. Blessing (February 1951). Reasonable standardization needs in the mapping and surveying procedures of planning commissions in all cities—large and small. Discussers: Harold M. Lewis, Leon T. Eliel, and Charles A. Blessing. (Available February 1.)

D-62. Discussion of Paper, **The New Towns Program in Great Britain,** by T. C. Coote (March 1951). Description of the planning of fourteen new towns in Great Britain erected by development corporations employing their own staffs or by outside consultants. Discussers: W. Strickler, and T. C. Coote. (Available February 1.)

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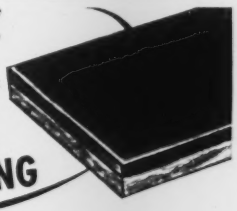

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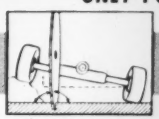

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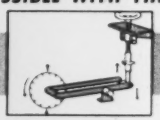

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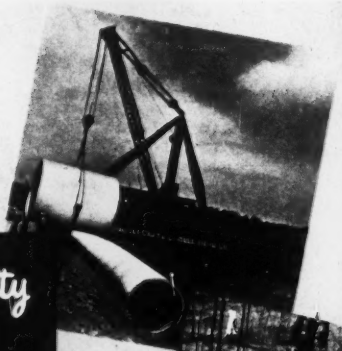

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